Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

MULTIPLE-PRODUCT PROCESSING OF CALIFORNIA FROZEN VEGETABLES

Part A: Analysis of Operations and Costs

Part B: Supplement—Labor and Equipment Standards and Requirements For Preparation and Packaging

Robert H. Reed and L. L. Sammet

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Robert H. Reed and L. L. Sammet

FOREWORD

This is the ninth in a series of research reports by the University of California on the competitive position of the western frozen fruit and vegetable industry conducted under a regional research project by the Agricultural Experiment Stations of California, Oregon, and Washington in cooperation with the Economic Research Service, U. S. Department of Agriculture.

The two major objectives in this report are: (1) the adaptation of previously developed modifications of conventional theory of the firm to provide a theoretical and methodological approach to cost measurement in multiple-product plants and (2) to apply this approach in an analysis of operations and costs in frozen vegetable plants.

Economic and engineering research procedures are used in a synthesis of costs for a series of different plants designed for single-product output of six major frozen vegetables. These are broccoli, Brussels sprouts, green peas, lima beans, snap beans, and spinach. Each analysis is limited to the costs and efficiency of in-plant operations and centers on the development of long-run cost or planning functions. The results of the single-product analyses are then applied to operations in multiple-product plants processing selected combinations of the six frozen vegetables chosen for study.

This report should supply useful information to management of individual firms in efforts to improve operating efficiency, in planning new investments, and in determining short-run adjustments in product mix. The results also are being applied in continuing studies of interregional competition in the frozen vegetable industry.

ACKNOWLEDGMENTS

As numerous individuals were associated with this work, full acknowledgment of their contributions is desired. Genuine appreciation is due C. C. Dennis, R. Sandoval, and T. Worley for aid in the collection of basic data; to R. G. Bressler, Jr., for his stimulation and help in the earlier phases of the study; to L. C. Martin of the Economic Research Service; and to members of the WM-17 Regional Technical Committee. Special credit is due B. C. French, who offered valuable help and constructive criticism of the manuscript at all points of its development.

Essential contributions to the study were made by the California frozen food industry. While it is difficult to single out individuals in this connection, the authors wish to extend particular thanks to the following individuals and organizations: R. Beverly, Food Machinery Corporation; E. Boone, John Inglis Frozen Foods Company; C. Calleros, Sacramento Freezers, Inc.; K. M. Eberts, Stokely-Van Camp, Inc.; R. G. Free, California Consumers Corporation; V. Gross, Spiegl Farms, Inc.; G. Harris, Walnut Creek Sheet Metal Co.; N. Josovich and Company; J. Q. Leavitt and Company; J. C. Martin, Knudsen Frozen Foods, Inc.; R. A. Shaw, Watsonville Canning & Frozen Food Company; L. States, Ocean Shore Iron Works; and F. B. Voit, Patterson Frozen Foods, Inc.

Although this work has benefited from many helpful suggestions and has borrowed freely the ideas of many individuals, the authors assume full responsibility for the analysis and results presented.

PUBLICATIONS IN THIS SERIES ON ECONOMIC ASPECTS
OF THE FREEZING OF FRUITS AND VEGETABLES IN THE WESTERN REGION

Listed below are items published under a cooperative program of the Agricultural Experiment Station, University of California, and the Economic Research Service, U. S. Department of Agriculture.

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Dennis, C. C. An Analysis of Costs in Processing Strawberries for Freezing. University of California, Giannini Foundation Mimeographed Report No. 210. Berkeley, 1958.

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Dennis, C. C., and Sammet, L. L. "Interregional Competition in the Frozen Strawberry Industry," Hilgardia, vol. 31, no. 15 (December, 1961), 499-604p.

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MULTIPLE-PRODUCT PROCESSING OF CALIFORNIA FROZEN VEGETABLES
PART A. ANALYSIS OF OPERATIONS AND COSTS

by

Robert H. Reed[1/] and L. L. Sammet[2/]

I. INTRODUCTION

The period since World War II has been one of rapid development and growth in the production of frozen vegetables, particularly in California where frozen vegetable production has more than quadrupled since 1946. This has required important adjustments in the farm production of raw materials for processing and large new investments by frozen food processors. As most frozen vegetable production is sold in the more heavily populated eastern states, processors in California and elsewhere in the West face intense competition from plants located much closer to major markets. Understanding the implications of further growth and the development of sound investment decisions by individual firms is of great importance to the future course of the frozen vegetable industry in the western states.

An important part of this broad problem is analysis of the costs of processing frozen vegetables, with emphasis on maintaining and improving plant efficiency in the West.[3/] This involves study of the major factors affecting costs of processing, including detailed analysis of comparative costs among alternative processing techniques in relation to the number and type of products processed, capacity output rates, and number of hours operated per season. Additional considerations are the effect of the quality of raw product, form of output, style of pack, and other variables on the costs of processing frozen vegetables.

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1/ Agricultural Economist, Marketing Economics Division, Economic Research Service, U. S. Department of Agriculture, and Associate in the Experiment Station, University of California, Berkeley.

2/ Professor of Agricultural Economics, Director of the Giannini Foundation, and Agricultural Economist and Agricultural Engineer in the Experiment Station, University of California, Berkeley.

3/ The term "processing" as used in this report includes all plant activities involved in receiving, preparing, packaging, and freezing vegetables.

This report is designed to show how variations in these factors affect costs of processing selected frozen vegetables and to present data useful for processors and others interested in planning new investment, such as new construction or changes in existing plant facilities and techniques. It is also intended to provide data suitable for estimating processing costs in different geographic regions, thereby contributing to current studies of interregional competition in this industry.

1. Selection of Products and Sources of Data

Broccoli, Brussels sprouts, green peas, lima beans, snap beans, and spinach--normally a substantial part of the product mix in most California freezing plants--are selected for detailed analysis. These six vegetables represent about 85 percent of the current California pack of all frozen vegetables.

Data representing a wide range in plant operating characteristics, product organization, and design were obtained in cooperation with 10 California freezing plants. Supplementary data for certain job and equipment categories were taken from previous studies of frozen strawberry processing and fresh deciduous fruit packing operations. Additional data were obtained from major equipment companies, local manufacturers, and contractors.

2. Operating Seasons and General Output Characteristics of Plants Freezing the Vegetables Studied

To provide a setting for the empirical studies, the California vegetable freezing industry is described in terms of operating seasons, grades and forms of output, and container styles in plants processing the six vegetables considered.

Operating Seasons

As seasonal distribution of plant operations varies with location, type of product, and climatic conditions, plant operating seasons cannot be specified with any degree of precision. Table 1, however, gives operating seasons

TABLE 1

Selected Frozen Vegetable Plants: Operating Seasons and Number of Days and Hours Operated
California, 1960

Products	Season calendar dates				Number of days operated per plant			Number of hours operated per plant		
	Earliest start	Latest ending	Average start	Average ending	Maximum	Least	Average	Maximum	Least	Average
Fordhook lima beans	8/1	11/13	8/15	10/20	60	16	41	786	302	469
Baby lima beans	8/2	11/1	8/15	10/20	53	5	31	372	89	258
Green peas	3/25	6/7	4/25	5/30	39	15	29	258	64	230
Spinach					127	6	45	664	72	369
Spring	1/11	6/3	3/20	4/25						
Fall	9/21	1/1	10/15	12/25						
Snap beans	6/23	10/9	7/1	8/25	60	13	40	690	208	325
Broccoli					139	16	83	962	241	570
Spring	1/2	6/30	2/15	3/25						
Fall	10/25	12/29	11/20	12/15						
Brussels sprouts	8/25	1/27	9/10	12/25	120	12	63	1,070	83	491

Source: Robert H. Reed, Survey of the Pacific Coast Frozen Fruit and Vegetable Processing Industry, University of California, Giannini Foundation Mimeographed Report No. 198 (Berkeley, 1957), 36p.

for the six vegetables based on average industry experience for 1955.[1/] The packing season is concentrated in the fall and spring months. June and January are relatively idle periods. Broccoli and Brussels sprouts have processing seasons that correspond over several months, and the remaining vegetables have short seasons of four to eight weeks' duration. In terms of average hours of plant operation per season, broccoli ranks first, followed in order by Brussels sprouts, Fordhook lima beans, spinach, snap beans, baby lima beans, and green peas. Operating seasons for individual plants vary considerably from these averages.

Table 1 indicates some of the possibilities for increasing the length of season by diversification with respect to commodities packed. Moreover, most of the vegetables are somewhat flexible with regard to planting and harvesting dates, and many operators are able to schedule harvesting dates so as to avoid, partially or wholly, serious peaks, shortages, and overlaps. This permits most California plants to pack several commodities and to operate almost on a full-year basis.

Container Styles

Frozen vegetables are packed in three container styles--retail, institutional, and bulk. The retail container varies from 8 ounces to 1 pound according to the commodity or trade practice. The institutional pack varies from 2 to 10 pounds but normally is packaged in 2-, $2\frac{1}{2}$-, or 3-pound paper cartons. Recently, a portion of the institutional style has been packed in polyethylene bags. Bulk packages cover the range from 10 through 60 pounds.

Figure 1 shows the proportions of the total annual volume of the six selected vegetables packed in the various container styles for the period 1948-1958. Only lima beans, snap beans, and green peas are packed in bulk style. These products are packaged easily in individually quick frozen (IQF) form, which makes them particularly adaptable for bulk packaging and for recombining in such products as mixed vegetables, succotash, specialty foods, and soups. Conversely, broccoli, Brussels sprouts, and spinach

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1/ For additional details regarding the characteristics of the California freezing industry, as well as that of Washington and Oregon, see Robert H. Reed, Survey of the Pacific Coast Frozen Fruit and Vegetable Processing Industry, University of California, Giannini Foundation Mimeographed Report No. 198 (Berkeley, 1957), 36p.

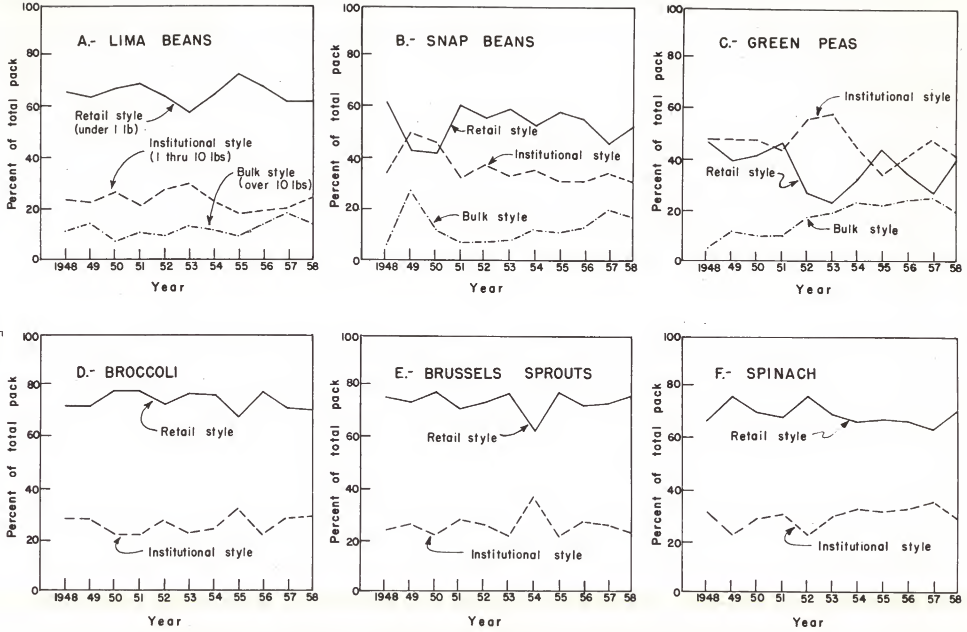

Figure 1. Proportion of Total Frozen Vegetable Production Packed in Retail, Institutional, and Bulk Containers, California, 1948-1958.

usually are frozen by wet-pack methods, are not readily adaptable to bulk-style packaging, and are not currently in demand as separate ingredients for frozen food mixes.

The proportions packed in the different container styles have remained relatively constant for broccoli, Brussels sprouts, and spinach. Over the 11-year period, the proportion packed in retail containers has averaged 74 percent for both broccoli and Brussels sprouts and about 70 percent for spinach. The proportions of lima beans packed in the various styles have also remained relatively constant around a mean of 65 percent retail, 23 percent institutional, and 12 percent bulk. A similar situation is evident for snap beans, particularly since 1950. With the exception of bulk-style packaging, which is on a relatively smooth upward trend, the proportions of green peas packed in retail and institutional containers have been erratic over the 11-year span.

In individual plants, on any given operating day, the proportions packed in the various styles depend on many factors, including raw product quality and volume of receipts, volume and urgency of unfilled orders, and inventory position. This leads to considerable variation in the daily performance of individual plants in regard to different grades and containers for each of the vegetables processed, and plants usually are designed to operate with considerable flexibility.

Forms and Grades of Output

In addition to the container styles described above, frozen vegetables also are packed in a variety of forms and grades.[1/] Broccoli is packed in three forms--spears, cuts or chopped, and pieces. Spinach is packed in either whole leaf or chopped form, while snap beans may be packed whole, sliced lengthwise (French, julienne, or shoestring), or as cuts. No statistics are published on the relative proportion of the total pack these forms comprise.

The U. S. Department of Agriculture has established grades for frozen vegetables. Standards have been published for U. S. Grades A, B, and C and

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1/ Definitions of the various product forms and procedures for determining product grade have been published by the U. S. Department of Agriculture and are found in the appropriate issues by type of frozen vegetables.

substandard.[1] These grades are determined in relation to attributes such as color, absence of defects, uniformity of size, and product character. Although U. S. grades may be taken as the industry standard for most vegetables, some packers and buyers have established their own specifications that may be considerably above United States levels with respect to color and trim requirements.

II. THEORETICAL AND METHODOLOGICAL FRAMEWORK

The analytical framework for studies of plant costs and efficiency is provided by the conventional theory of production.[2] The usual formulation of the theory assumes that there is a given technology, with a variety of techniques for performing specific operations; there is a known structure of prices for the products produced and for the inputs used; any given variable input and output is homogeneous and perfectly divisible; there is some degree of substitution among factor inputs and product outputs; production and sales are simultaneous so that no accumulations of capital or stocks of inputs are required prior to the start of production; and there is no carry-over of production factors between successive production periods. A static

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1/ Ibid.

2/ Detailed treatment of the conventional theory of production is given in such works as:

Sune Carlson, A Study on the Pure Theory of Production (New York: Kelley and Millman, Inc., 1956), 128p.

Paul Anthony Samuelson, Foundations of Economic Analysis ("Harvard Economic Studies," vol. 80; Cambridge: Harvard University Press, 1947), 447p.

R. G. D. Allen, Mathematical Economics (London: Macmillan & Co., Ltd., 1956), 768p.

Kenneth Ewart Boulding, Economic Analysis (3d ed.; New York: Harper & Brothers, 1955), 905p.

J. R. Hicks, Value and Capital: An Inquiry into Some Fundamental Principles of Economic Theory (2d ed.; Oxford: Clarendon Press, 1946), 340p.

James M. Henderson and Richard E. Quandt, Microeconomic Theory: A Mathematical Approach (New York: McGraw-Hill Book Company, 1958), 291p.

Erich Schneider, Pricing and Equilibrium: An Introduction to Static and Dynamic Analysis, trans. T. W. Hutchison (New York: Macmillan Company, 1952), 327p.

long-run situation is recognized in which all inputs are variable, there is a static short-run in which one or more of the inputs are fixed in amount, and production is organized with the objective of maximizing money profit. The problem involves determination of the optimum combination of inputs for producing any given set of products in a specified product mix and the optimum (profit maximizing) amounts and proportions of the products to produce.

In recent years, the theory has been adapted in several important areas for use in particular empiric research problems.1/ The essential nature of these adaptations is more conveniently summarized in terms of a single-product output. Extension directly or in modified form then provides a theoretical and methodological framework for cost measurement in multiple-product plants.

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1/ Various modifications of conventional theory have been extensively discussed in the literature. Particular reference is made to the following:

George J. Stigler, "Production and Distribution in the Short Run," Journal of Political Economy, vol. 47, no. 3, June, 1939, pp. 305-327.

Hans Brems, "A Discontinuous Cost Function," American Economic Review, vol. 42, no. 4, September, 1952, pp. 577-586.

John S. Henderson, "Marginal Productivity Analysis: A Defect and a Remedy," Econometrica, vol. 21, no. 1, January, 1953, pp. 155-168.

Joel Dean, The Relation of Cost to Output for a Leather Belt Shop, Technical Paper No. 2 (New York: National Bureau of Economic Research, 1941), 72p.

B. C. French, L. L. Sammet, and R. G. Bressler, Jr., "Economic Efficiency in Plant Operations with Special Reference to the Marketing of California Pears," Hilgardia, vol. 24, no. 19, July, 1956, 543-721p.

R. G. Bressler, Jr., Efficiency in the Production of Marketing Services ("Social Science Research Council Project in Agricultural Economics: Economic Efficiency Series," Paper No. 6; Chicago: University of Chicago, 1950), 67p.

L. John Kutish, "A Theory of Production in the Short Run," Journal of Political Economy, vol. 61, no. 1, February, 1953, pp. 25-42.

Manuel Gottlieb, "On the Short-Run Cost Function," Journal of Industrial Economics, vol. 8, no. 3, June, 1960, pp. 241-248.

M. J. Farrell, "The Measurement of Productive Efficiency," Journal of the Royal Statistical Society, Series A (General), vol. 120, Part 3, 1957, pp. 253-282.

A statement relative to multiplant firms will be found in Don Patinkin, "Multiple-Plant Firms, Cartels, and Imperfect Competition," Quarterly Journal of Economics, vol. 61, no. 2, February, 1947, pp. 173-205.

1. Single-Product Plants

Appropriate modifications of the basic theory of single-product output rest on the types of technical organization that characterize agricultural processing plants.1/ These plants generally are organized on a product-flow basis, in which more or less continuous streams of raw product and other materials are carried past a series of machine or work stations. At each such station various transformations and combinations are accomplished in a planned sequence. The end product, or products, emerges from the final station.

Such processes may conveniently be viewed as a series of identifiable subprocesses or stages that, as an integrated aggregate, comprise the plant.2/ If the stages are so defined as to be technically independent for analytical purposes, the output of one stage becomes an input of the next. The basic cost-output relationships with alternative production techniques then may be determined at each stage level.

Another important contrast is the means used to vary output. In the basic theory, only instantaneous rate of output is variable, and this is accomplished in the short run by varying the proportions and level of the variable inputs combined with a given fixed factor. With completely divisible inputs and output, the input-output relationship is continuous; and, with variation in the intensity of utilization of the fixed factor, this relationship is curvilinear.

Different means of output variation are, however, observed in most processing plants. Because of storage or other delays in the disposal of product, production is not simultaneous with consumption. Time of operation then may be utilized to adjust the level of output in a given production period, or season, and the dimensions of output variation include both instantaneous rate

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1/ This entire section draws heavily from the references cited above, particularly Brems, op. cit.; French, Sammet, and Bressler, op. cit.; and L. L. Sammet, "Economic and Engineering Factors in Agricultural Processing Plant Design" (unpublished Ph.D. dissertation, Department of Agricultural Economics, University of California, 1958), pp. 47-307.

2/ Brems, op. cit., refers to the coordination of inputs of varying capacities as the problem of harmony. With perfect harmony among all stages, all inputs would be fully utilized, and there would be no idle time or underutilized capacity.

and length of operating period. The short-run input-output relationship then may be curvilinear in the rate dimension but linear in relation to hours of operation at any given rate of plant output.

Modification also is necessary in regard to the nature of input variation. Rather than complete divisibility, the various factors of production often are available only in discrete units of relatively fixed capacities, and they may be susceptible to combination only in fixed proportions, for example, one machine, one operator. Input-output relationships then are discontinuous, with each increment of input involving a stepwise relation to output, and the total input-output relationship tends to be linear.

Still another distinguishing characteristic of processing plant organization is that given stages of the production line may consist of a set of identical machines or work stations arranged in parallel so that the total product flow is divided among them. Rate of product flow may be varied, up to the capacity of the limiting stage, by varying the number of machines used in a multiunit stage. Similarly, the plant may consist of several production lines rather than one, and the rate of plant output may be varied in terms of the number of production lines utilized. If each such multiple unit--a machine within a given stage or the production line as a whole--is utilized at an essentially constant rate, input-output variation within a given production line or among several production lines is discontinuous and again tends strongly to be linear.[1/]

Modifications also are appropriate in regard to the usual criteria of profit maximization.[2/] When cost and revenue functions are continuous and simultaneous, short-run profit maximization occurs at the output rate that equates marginal revenue and marginal cost. But, with important discontinuities in the variable cost function, short-run profit maximization may occur at an output rate where marginal revenue and cost are unequal. In this

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1/ This characteristic of plant organization has been defined as "segmentation." See Brems, op. cit.; Dean, Statistical Cost Functions of a Hosiery Mill ("Studies in Business Administration," vol. 11, no. 4; Chicago: University of Chicago Press, 1941), p. 7; and French, Sammet, and Bressler, op. cit., p. 555.

2/ In this condensed statement, it is convenient to assume simple profit maximization as the goal of the firm. However, other widely recognized modifications of the basic theory recognize alternative goals, for example, maximization of common shareholders' wealth or achievement of an income-leisure balance or an income-risk balance. For further qualifications, see page 30.

event, discrete examination of cost-revenue relationships along the entire range of output rates may be required.[1]

A modified profit-maximizing solution also applies if production and sale are not simultaneous and output in a given period is varied over time. Consideration then may be required of the effects of variation in rate of output, as above, along with variation in number of hours operated on a standard-shift basis and on second or third shifts (with the possibility of wage differentials among shifts) or number of hours of overtime operation at premium wage rates. With multiple-shift or overtime operation, differences in productivity as compared with a standard daytime shift may also affect the solution.

These time-rate relationships are demonstrated, in part, in Figure 2.[2] Here, the determination of profit-maximizing adjustments with three selected levels of demand is presented in terms of marginal costs and revenues. Considering first the marginal cost curve, the portion O'a represents the constant marginal costs obtained by operating varying hours per period at the minimum average cost rate of output. The curved segment, ac, represents the increasing marginal cost as total volume per period is expanded by increasing the output rate beyond the minimum average cost level, while the portion cd represents the higher constant marginal costs obtained by operating at the minimum cost rate of output but at overtime rates of pay. Productivity at regular and overtime wage rates is, in this illustration, assumed the same.

Profit-maximizing adjustment with respect to total volume of output per period, rate of output, and time operated per period can be determined by equating marginal revenue and marginal cost, both measured in relation to total volume per period, for each of the three situations illustrated. With the level of demand reflected by MR_1, optimum output is OQ_1 at an output rate corresponding to minimum average cost with straight-time wage payments for the period less than or equal to the total amount of time available. The intersection of MR_2 and marginal cost occurs in the curvilinear portion of the marginal cost curve at a point corresponding to a total output per period of OQ_2. This volume can be produced most profitably by limiting the operation

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1/ French, Sammet, and Bressler, op. cit., p. 554.

2/ The diagram, as well as the summary discussion given here, follows that given in Sammet, op. cit., pp. 79-86. The nature of these adjustments are also discussed in Kutish, op. cit.

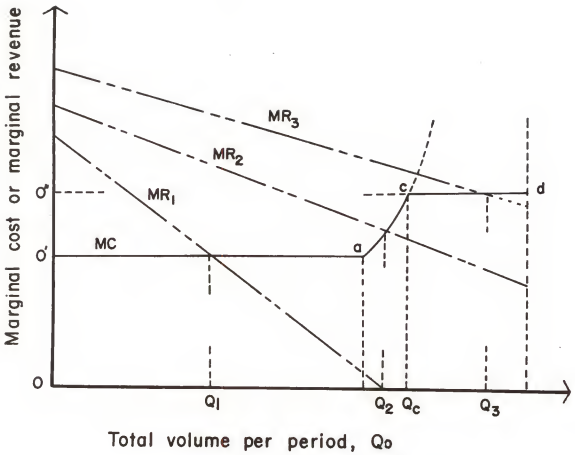

Figure 2. Marginal Revenue and Marginal Cost Relationships with Expansion of Output per Period Through Variation of Straight-Time and Overtime Hours Worked, California, 1960.

to straight-time hours but intensifying the rate of output. With MR_3, profit maximization occurs with total output per period at OQ_3. This volume involves production at the minimum average cost rate of output for the full amount of straight-time operation (marginal cost curve OO'), with the remaining output produced at the same rate but at the overtime cost level indicated by OO".

The effects of shift differentials in cost rates or of changes in productivity as hours worked per day are varied could be similarly evaluated. Moreover, if the variation in number of hours operated per season requires large storage operations, their costs would need to be considered in the solution.

In empiric applications of the basic theory to the long-run situation, account must be taken of changes in the relative magnitudes of the fixed and variable inputs and their costs as time operated per period and rate of output change. This requires consideration of cost and revenue relationships over the full use life of the durable input. As use of a given durable factor usually will extend over several operating seasons, the implications of uncertainty are of increased importance. One theoretical approach is to define the determinants of profits (costs and revenues) in any period in terms of expected, rather than certain, values. These estimated values for future periods then may be twice discounted--once in relation to the range and distribution of anticipated values, assuming an aversion to risk, and again for the time lapse to the future period. Output adjustment in future periods may be evaluated in terms of these discounted values, and judgments as to profitability of investment may be based on the total present value of net revenues obtained by summing the discounted values of net revenues for all future periods.[1]

Empiric analysis strictly in the above terms is virtually foreclosed by the absence of data concerning the nature of the variability of future costs and revenues. In studies of plant organization and costs, a useful simplification involves the allocation of investment and other capital charges to a "representative" production or accounting period. These charges include allowances for depreciation, taxes, insurance, interest on the undepreciated portion of the investment, and certain repairs and maintenance. Investment outlays in

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1/ The definition and measurement of capital inputs and costs have been extensively studied. See, for example, Friedrich and Vera Lutz, The Theory of Investment of the Firm (Princeton: Princeton University Press, 1951), 253p.; and Trygve Haavelmo, A Study in the Theory of Investment (Chicago: University of Chicago Press, 1960), 221p.

the form of depreciation charges enter into the long-run cost calculations as a fixed charge against the output of each period. Fixed charges for repairs and maintenance include only those related to time, while those attributed to use are more properly included as part of variable costs. Property taxes usually are assessed against an appraised value of property, and they constitute a fixed cost for any particular production or accounting period. Risks to which probabilities can be applied are considered in terms of insurance costs that are included in the long-run or planning cost estimates as part of the fixed costs per period. Lacking specific probability distributions, the implications of uncertainty and uninsured risks may be incorporated in the analysis through injection of alternative values for strategic variables.

The types of uncertainties to be faced include the future course of factor and product prices and of future technological development and its effect on obsolescence; the availability of raw product, including the scheduling of receipts and processing capacities; and sales and product quantities and qualities. These contribute to difficulties in planning. A widely practiced accommodation to uncertainty is the provision of flexibility and adaptability in design and organization so that considerable variation around the minimum cost rate of output is possible without large variations in average cost.[1/]

In the above discussion, it is evident that numerous assumptions underlie empirical studies of plant organization and costs. These stem in part from the fact that actual plants operate in a complicated organizational setting, conditioned by technical and institutional constraints. The assumptions and simplifications are necessary if the analysis is not to bog down in a maze of details. They are acceptable if made apparent and if meaningful results are not precluded.

Cost synthesis is an effective means of reflecting in plant cost functions the technical relationships and operating characteristics noted above. In this approach, economic-engineering research procedures combine elemental input-output and plant record data to develop cost-output relationships among individual operating stages with alternative production techniques. Comparison of such stage-cost functions provides the basis for selecting

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1/ For additional discussion, see Stigler, op. cit. A more complete discussion of flexibility and adaptability with respect to multiple-product plants is given in the next section of this study.

least-cost operating techniques and for the development of generalized long-run costs or planning functions for plants of various scales of output.

2. Multiple-Product Plants

The modifications of the conventional theory of single-product output summarized in the preceding section stress the time dimension and plant segmentation as a means of varying total output volume per production period as well as the discontinuous nature of production and cost functions and the problems of aggregation and integration of multiple processes or stages. Some attention also is given there to the practical aspects of pricing the services of durable goods, selecting from among alternative production techniques, and the need for plant flexibility and adaptability. With multiple-product plants, similar, although more complex, elaborations of the theory are essential.

Special Models

From a production or cost viewpoint, it is convenient to consider five cases, the characteristics of which may be determined by applying appropriate constraints in the more general solution. These include:[1] (1) multiple products with fixed proportions; (2) multiple products with separate and independent process lines; (3) multiple products with alternative use--in different time periods--of the same or slightly altered facilities; (4) multiple products with simultaneous and joint use of all or part of a given process or line; and (5) combinations of the above.

Types of organization other than those enumerated may be found, but the listed classifications either include the functional relationships likely to be encountered or can be adapted to fit particular situations.

Fixed Proportions

If two or more products are produced in fixed proportions, the analysis is analogous to that applied in the single-product case. The analysis of

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1/ The classification of cases or models follows in part that of Bressler, op. cit., and Schneider, op. cit., pp. 92-96.

technical and cost relationships is identical to that of single-product output because in each case the different relationships can be expressed as functions of a single output quantity. For example, if the output rates of Q_1, Q_2, and Q_3 are in fixed proportions--$Q_2/Q_1 = k_1$ and $Q_3/Q_1 = k_2$, where k_1 and k_2 are constants--output may be defined in terms of a composite output rate, X, comprised of k_1 units of Q_2, k_2 units of Q_3, and 1 unit of Q_1. The composite, X, may be treated as a single output, and a unique cost function can be derived exactly as described in the case of simple production. Total, marginal, and average costs can be calculated for the composite output, but these costs cannot be computed for each product except by some arbitrary allocative procedure.

With pure competition in the sale of products, optimum adjustment in the case of fixed proportions is analogous to the single-product case and requires no special treatment. Consider the three-product example discussed above. Designate P_1, P_2, and P_3 as the prices of the products and let $C(X)$ represent the cost function. The price of the composite unit, X, is then $P_1 + k_1P_2 + k_2P_3$, and the composite profit function is $(P_1 + k_1P_2 + k_2P_3)X - C(X)$. Under pure competition, maximum profits are obtained with that level of output at which the marginal cost of the composite unit, X, is equal to its price, that is, when $\partial C(X) = P_1 + k_1P_2 + k_2P_3$.

With imperfect competition in sale of products, optimization with fixed proportions is less simple. In this case, the quantities produced of one or several products, if fully sold, may result in negative marginal revenues. Optimum adjustment would require the waste or destruction of the supply of commodities beyond the point where marginal revenue falls to zero.

When time is introduced as a dimension in the above formulation, the necessary conditions for maximum profit per period are identical to the single-product solution discussed earlier (pages 11 and 12).1/

Independent Processes

Strictly interpreted, this model requires that the plant be organized into multiple production lines, each line or segmented series of lines

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1/ Note also the assumption that in any short-run situation the desired output can be produced with constant-rate operation at minimum average cost by operating $\underline{t}$ hours, where $t \leq k$, and k is the maximum time available during the period.

producing a different product and employing a different process. The simple process flow diagram shown in Figure 3-A illustrates the extreme case of two processes sharing the same building but with other inputs and costs specialized for each process. Optimum input and cost-output relationships would be determined for each line separately just as in the one-product case. With independent processes of the type described, the total cost function for the product mix would appear as the sum of the cost functions for each specialized processing line and a constant term representing the joint costs of sharing the building.1/

Alternative Production with Like Processes

With this model, the processes for different products are similar, and they can be produced with essentially the same facilities but in different time periods. This is a common type of multiple-product organization in plants processing agricultural commodities. Plants may be organized as illustrated in part A or part B of Figure 3, recognizing that each line is adaptable for processing two or more products in different and independent time periods. To process the products without building duplicate facilities, plant operations with alternative products must be scheduled at different and independent time intervals or seasons.

Variable costs for each product are uniquely determined for each independent time period, and the constant term of the total cost equation represents the joint costs of the shared fixed inputs. This implies a solution similar to the model discussed immediately above, the chief difference being the larger magnitude of jointly used inputs, primarily processing equipment.2/

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1/ Technically, independent processes are easily visualized, as in the above illustration. But joint costs in at least a few fixed inputs are hard to avoid. In this example, joint building costs might be "avoided" if separate structures were provided for each process. But this would almost inevitably leave joint costs for the plant site and for management and similar inputs.

2/ Serially independent operations with multiple products introduce an additional problem in cost synthesis. This is the problem of "balancing" line capacities used in producing each of the different products of a given mix so as to minimize underutilization of important common factors such as management and equipment. This difficulty arises in any multiple-product model that permits processing of alternative products in different and independent time periods.

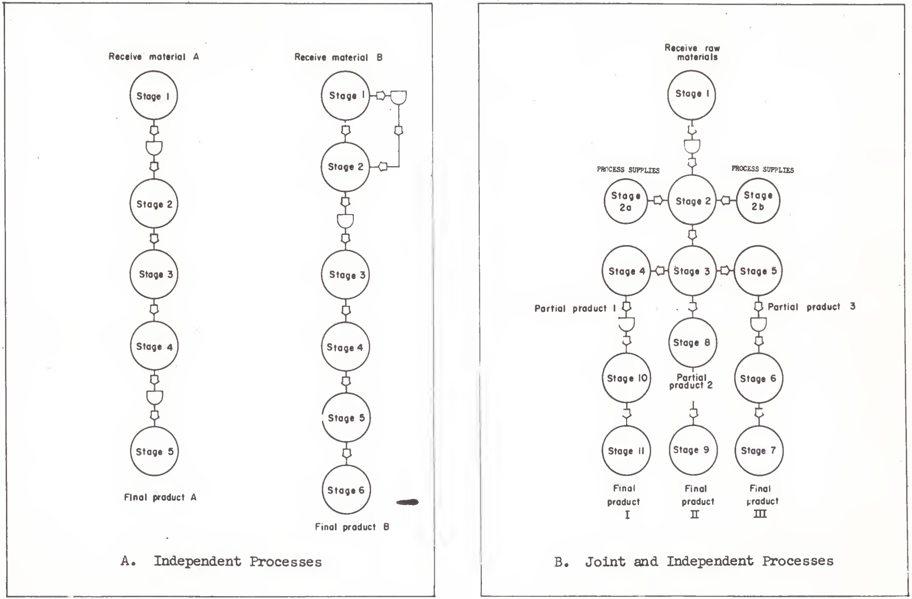

Figure 3. Product Flow Chart Showing Combinations of Independent Processes and Joint and Independent Processes in a Single Plant, California, 1960.

Related Outputs

This model describes a multiple-product plant organization in which simultaneous and joint use is made of all or part of a given process or production line and represents conditions frequently found in modern plant organization. A common example involves a type of organization where successive processes are applied to a common raw material up to some point in the processing line where two or more partial products are separated or split off into independent processes and are transformed into different final products. This type of operation is illustrated in Figure 3-B, in which operating stages 1 through 3 include operations common to the basic raw material. At stage 3 the basic material is separated into three partial products which are further transformed by independent processes and emerge as separate, finished products. The essential feature of this model is that each of the stages in the operation can be identified and studied separately.

If the final products are produced in fixed proportions, the specialized inputs of each stage could be related directly to a uniquely defined (composite) output and optimum input-output combinations and costs determined independently for each stage exactly as in the simple production and fixed proportions models discussed earlier.

When the basic material separates or divides in variable proportions, complications typical of joint or multiple relations arise. This creates real difficulty in cost measurement, as variable costs per period vary not only with instantaneous rates of output and hours operated but also with the proportions produced of the various end products. In the single-product and fixed proportions models, it is recalled, assuming certain constraints, that net revenue will be maximized by operating the plant at a constant output rate corresponding to minimum average cost.1/ Where the nature of the basic raw materials permits wide variations in the proportions of end products, the flow of subproducts in the branch lines is variable, even though raw product volume is held constant. Unless input and cost-output relationships in the branch lines are completely independent of output rate, such variations in product proportions will affect total cost and will shift the marginal cost relationships among the various partial and end products.

1/ See pages 11 and 12.

The conceptual difficulties inherent in production with variable proportions are no less evident in theoretical considerations than in actual practice, and means of reducing the complexity of technical interrelationships are sought by plant operators in the design and organization of their plants. A meaningful approach to the problem of related outputs requires consideration of the nature of the material processed and the processes involved from an engineering viewpoint. In many actual situations, flexibility in plant organization may greatly reduce the effects of variable proportions. If permitted by the physical nature of the product, temporary storage operations, for example, may be used to obtain a more uniform flow of material throughout the combined processes. In the present example (Figure 3-B), temporary storage of the partial products could be used to build up reserves or for the withdrawal of surpluses as required for a more even-flow operation of each of the branch lines. Stricter segregation of grades of the basic material received into similar lots to be run separately through the plant is another means commonly employed, particularly in agricultural processing plants. This is a variant of the segmentation concept, in which, by appropriate production scheduling, the characteristics of raw or finished products may vary among different sub time periods--say an hour, day, or week--but be made relatively uniform within a given time period. Adaptability of the plant to this type of operation frequently will be easier if physical segmentation of the plant within given operating stages or in terms of replication of complete processing lines is provided.

The net result with flexible plants of the types discussed is that within a given output segment the conditions leading to a solution based on constant-rate operation for each process are closely approached in many instances. A solution similar to the single-product or fixed proportions case can be developed within this modified framework. The additional costs incurred in providing flexible facilities are, of course, incorporated in the plant cost estimates.

Combination Models

Any one or more of the models discussed above may be present in a plant. Although this makes more complex the empirical estimation of input and cost relationships, the framework of analysis needs no further extension. The problem can be analyzed in a series of relatively independent studies and

finally aggregated to include all products and processes. Problems of flexibility, adaptability, and stage integration encountered in plant design for such circumstances may require the application of more engineering knowledge as compared with other models, but the procedures are essentially unchanged.

Scale of Output with Multiple Products

Where products are closely related with respect to their physical characteristics and in the processing facilities required, a long-run cost or planning equation relating total average costs for a given product mix to the rate of combined output and length of operating period may be developed. Under these conditions, scale of plant with multiple products is approximated in a single-output dimension, and economies of product diversification may be determined by comparing average planning costs for plants processing a specified product mix with unit planning costs for more specialized operations.

This simplification is not generally applicable, however, as the individual outputs of a multiple-product plant often cannot be measured meaningfully in terms of combined weight. In these circumstances, conceptual problems regarding the definition and measurement of plant scale arise, as it is no longer expressed in a single-output dimension. In practical solutions of problems of long-run adjustment, plant scale in terms of a uniquely defined output variable is frequently measured in terms of output equivalents, ratios, or by the use of an output index.

Allocation of Costs

With any form of multiple-product output, there will be some joint costs. As indicated earlier, these costs cannot be computed for each product except by some arbitrary allocative procedure. However, the nature of the plant processes, methods of analysis used, and types of plant organization considered in this study are such that a large percentage of the variable inputs and many of the equipment and durable items can be specifically related to particular products. The allocative procedure--whatever it may be--is applicable only to a small proportion of total costs. The effects of arbitrary allocation procedures can be calculated and shown to be minor.

3. Organization of the Study and Method of Analysis

The preceding models may be used as a framework of quantitative cost synthesis. In the following pages, economic and engineering research procedures are used in their application to measurement and synthesis of input requirements and costs in California vegetable freezing plants.[1/] The analysis is limited to in-plant operations only. Demand, price, and revenue relationships and costs associated with raw product procurement are not considered nor are selling activities and costs.[2/]

Initially, attention is focused on the synthesis of costs for a series of different processing plants designed for single-product output of each of the vegetables studied.[3/] The objectives center on the development of long-run cost or planning functions and involve detailed analyses of comparative costs among alternative production techniques in relation to capacity output rates and number of hours operated per season. Additional consideration is given to the effects of quality of raw product, style of container, form of output, and other cost determinants.

The results of the single-product plant analyses are then applied directly, or in modified form, to operations in multiple-product plants processing selected combinations of the six frozen vegetables chosen for study. Complete specification of processing costs in relation to the many possible combinations of products, output rates, annual operating hours, and types of plant organization is not attempted. However, a wide range of alternatives in the organization and design of plants processing combinations of the vegetables considered are represented within the framework of three general models.

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1/ For a detailed presentation of economic-engineering techniques in cost measurement, refer to French, Sammet, and Bressler, op. cit., pp. 543-721. See, also, Sammet, op. cit.

2/ Research in these areas is currently in progress, however, in separate but related studies.

3/ Vegetables include broccoli, Brussels sprouts, green peas, lima beans, snap beans, and spinach.

Model I--Multiple-product plants in which each preparation and packaging line is specialized for a given vegetable and the lines operate independently.

Model II--Multiple-product plants with processing lines that at any given time are operated on a single-product basis but which may be adapted for the processing of other vegetables in other, and independent, time periods.

Model III--Plants that combine the operational features of Models I and II.

Syntheses of costs of processing different combinations of products in plants conforming to the above models are compared, and the multiple-product cost relationships are compared with costs in specialized single-product plants.

Estimation of Input Standards and Requirements

Production standards for labor are derived from time and production studies wherever this technique is applicable to measure unit time required to perform a given operation, including minimum additional allowances for unproductive time such as rest periods, unavoidable delays, and personal time. For jobs not adapted to measurement by time and production studies, plant operating and record data are used to establish labor production standards.1/ These standards provide the basis for estimating crew requirements in relation to hourly output rates and methods used in each stage of plant operations.

Equipment requirements in plants of different line capacities and product organization are developed from production studies, plant operating data and equipment inventories, specifications of equipment manufacturers, and interviews with specialist personnel in freezing plants and equipment companies. Building requirements are estimated from engineering data obtained in studies of space requirements and layouts in plants of different capacity and organization. Requirements for management, plant administration, line

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1/ This category includes machine-paced jobs, supply men, utility workers, housekeeping workers, and hand-sort workers. Details are outlined in appropriate sections of the study.

supervision, quality control, and other general or indirect inputs are estimated from plant record data, observations of plant organization, and consultation with plant operators cooperating in the study.

The production standards and input requirements developed in this study, while less than maximum observed performance rates, represent a level of performance that can be maintained in plants organized to operate with a minimum unavoidable delay. As excess delay on some operations is present in most plants, the production standards and corresponding input-output relationships represent better-than-average performance levels observed in actual plant operation.

Cost Estimation

In the empiric portion of this study, certain simplifying assumptions and specifications have been used. Those relating to particular vegetables or types of plant organization are presented with the specific cost analyses. A specification applied generally is that output rate is constant throughout a given season and among different seasons. In actual plants, output rates may, of course, vary. However, the theory just outlined and observation of operating plants indicate a strong tendency toward operation at relatively constant rates near minimum average cost, with hours operated the principal volume variable.

Product quality and form of output with a given vegetable also are variable within and among seasons. Cost estimates developed for some plant stages provide means of estimating the effects of variation in raw product quality and form of final product. This would permit examination of a wide range in pattern of seasonal and year-to-year variations in raw product quality and form of final output and their effects on costs. However, the illustrations given of total plant cost relationships are limited to a single set of raw and finished product characteristics.

A further consideration in the analysis is that the technical organization of the plants visualized in the cost estimates provides flexibility in key stages, which permits considerable variation in raw product quality and in form of final output. While this results in slight elevation of estimated cost levels, it adds to the realism of the foregoing simplifications and is an arrangement consistent with practices observed in the plants studied.

Variable Costs

Variable costs include expenses for labor, materials, electric power, variable repairs, and other expense directly related to volume of output.1/ Hourly variable costs for plants processing the specified vegetables are calculated in relation to methods used and other operating conditions by applying appropriate cost rates to the estimated quantities of the variable services required.2/ As demonstrated later, variable costs usually may be treated as independent among products in multiple-product plants.

Investment Costs

Installed equipment replacement costs with different methods, line capacities, and product organization are calculated by applying cost rates obtained from equipment manufacturers and contractors to the estimated quantities required of each item. Replacement costs of buildings, industrial piping, and electrical wiring are based on engineering estimates of the costs of constructing or installing required quantities of these services in plants of different capacities and product organization. Investment in land, highly variable in relation to plant location, was omitted in this study. If included on a standardized basis, it would raise the level of estimated costs without significant change in the indicated cost relationships.

Annual Fixed Costs

An annual fixed charge, expressed as a percent of investment cost, is used to reduce investment in equipment, buildings, and other durable instruments of production to an annual basis. These charges include allowances for depreciation, taxes, insurance, interest on investment, and fixed repairs

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1/ Factor prices are taken to be independent of quantity purchased. This is considered reasonable for this study: wage rates are fixed by union contract; the volume of purchase of the remaining major input--containers--is large enough even in the small plants to make volume discounts essentially the same regardless of plant size.

2/ Cost rates and methods of estimating variable costs are set forth in appropriate sections of the analyses that follow.

and maintenance.[1] Annual fixed costs also include salaried management, superintendents, and office and clerical personnel; rental charges for certain items of processing equipment; and interest on short-term loans that may be required to pay current operating expenses.[2]

Total Annual Plant Planning Costs

Estimation of total annual costs is facilitated by combining closely related operations involved in processing each product or product mix into several stages or components and making a separate analysis of each. Total annual costs for each operating stage used in processing a given product, related to methods used, hourly rates of output, and length of season, are calculated by multiplying the hourly variable costs by the hours operated per season and adding the annual fixed charge. These cost estimates provide the

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1/ A straight-line formulation of depreciation rate is used. Other means of estimation might be employed, for example, an annuity with a present value equal to the depreciable amount. In view of other approximations in the estimating procedure--for example, estimation of use life of equipment--the refinement of the more elaborate depreciation schemes does not appear justifiable. Estimation of use life was based on evidence from accounting records and the judgment of "experts" such as plant managers and engineers. In selecting these values, the level of maintenance represented by estimated repair costs was considered. A sufficiently long use life was projected for buildings and equipment to warrant the assumption of zero salvage value at the end of the use period.

Taxes were estimated at a rate representing levels observed in the plants studied. Estimated insurance rates were based on quotations from insurance carriers as to rates on "typical" plant installations (taking account of type of construction, inventory, plant activities, location, and fire protection services available). Interest on investment was entered as a cost representative of current charges on long-term loans of the type applicable to food processing activities. Repair cost rates are approximations based on rate of outlay observed in some of the cooperating plants.

2/ Interest on operating capital is properly classified as a fixed cost. However, its amount is highly variable among firms, and adequate data concerning "typical" levels in relation to size of firm were not available. Omission of this item does not, however, impair the usefulness of the general cost relationships obtained.

basis for comparing relative costs of different methods of operation and for selection of the most efficient organization for each stage considered.[1]

Aggregation of costs representing efficient stage organization, along with general cost components not associated with specific operating stages, gives total annual cost for the entire plant. By defining individual stages so as to be essentially independent in terms of cost--as was done in this study--the aggregation involves thereby a summation of costs for the selected technique in each stage. Such cost estimates, related to size of plant, length of operating season, and other conditions of plant operation, comprise the total annual cost of in-plant processing and may be developed for any given combination of the six vegetables considered. The resulting point estimates of total annual costs are referred to as <u>planning costs</u>, and equations representing these relationships are defined as <u>planning cost equations</u>.[2] These do not represent the costs experienced in a particular plant or group of plants. Rather, they express the level of costs attainable in efficient plants of single- or multiple-product type.

Average planning costs in specialized single-product plants are found by dividing total annual cost by the number of pounds of the particular vegetable packed. With multiple products, average planning costs are estimated by dividing the total annual cost of any given product mix by the combined weight of the products packed.[3]

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1/ Efficient organization as used here involves selecting from among alternative methods or techniques that combination which will result in the least cost for any specified output rate (size of operation) and length of operating season.

2/ Except for manual grading stages, the planning cost equations developed in this study were fitted by the method of least squares. Those for the manual grading stages were fitted by graphical procedures. The corrected multiple correlation coefficients of the regression equations so developed ranged between 0.9566 and 0.9997 and indicate the equations give a close description of the synthesized cost points representing efficient plant organization. The correlation coefficients are not, however, a statistical measure of the validity of the cost estimates.

3/ Combined weight is expressed in terms of packed weight equivalent. See page 21 for further discussion of scale of output measurement in multiple-product plants.

III. SYNTHESIS OF COSTS IN SPECIALIZED FROZEN VEGETABLE PLANTS

In Part III, specific operations in the processing of frozen broccoli, Brussels sprouts, lima beans, green peas, snap beans, and spinach are analyzed in detail for plants organized on a specialized single-product basis.

Similar flow patterns are involved in processing each of the vegetables considered, but the operations performed within and among certain operating stages may vary widely, particularly in the preparation and packaging stages.[1/] These variations are indicated in the following summary of operations involved in these stages. In summarizing the various operations in preparing and packaging the vegetables specified, it is convenient to classify the vegetables into two general groups--free-flowing and hand-paced.[2/] Lima beans, green peas, and snap beans are classified as free-flowing items. Broccoli, Brussels sprouts, and spinach are placed in the hand-paced category.

Free-flowing items are received in bulk containers--pallet bins, trailers, or dump trucks. At the plant receiving station, bins are unloaded by mechanical fork trucks and either set aside to temporary storage or placed directly on mechanical bin-dumping equipment. Trailers and dump trucks are emptied directly into a receiving tank or hopper. Free-flowing products are conveyed through a series of integrated in-plant operations performed almost entirely by mechanical means. Lima beans and green peas, for example, are normally moved by pumps, flumes, or belts through pneumatic and hydro cleaning equipment, quality graders, and hot-water blanchers. After blanching, the beans and peas are flume cooled; manually inspected for defective pieces or foreign matter that may remain after mechanical quality grading; and pumped, flumed, or otherwise conveyed to automatic filling and packaging equipment. Aside from initial operations that involve size grading and snipping, snap beans follow essentially the same flow

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1/ Preparation and packaging stages as used in this study include receiving, initial cleaning, size grading, cutting, snipping, blanching, quality grading, cooling, filling and check-weighing, and wrapping.

2/ This classification may be applied to many vegetables and other products not considered here. For example, cut corn, juices, and soup products may be included in the free-flowing category, while asparagus, cob corn, southern greens, and cauliflower are additional examples of hand-paced items. Any given product may overlap into the other classification for some operations.

pattern. As snap beans are processed in several forms, however, additional operations include cutting or slicing.

Hand-paced products are also received in bulk. Bins, trailers, baskets, and flatbed trucks are the most common types of containers used. Mechanical fork trucks and dumping equipment are used in handling bins, while trailers, baskets, and flatbed trucks are mechanically tip-dumped or hand-forked. The methods of in-plant processing and handling of hand-paced items are similar to those involved with free-flowing products but require larger labor inputs in most stages of preparation and packaging. Broccoli and Brussels sprouts, for example, are manually trimmed and cut to specified lengths. The packaging and filling operations for leaf spinach and broccoli spears are also performed manually--an operation that requires large amounts of labor. Conversely, Brussels sprouts, chopped broccoli, and chopped spinach are filled by mechanical means and in this respect resemble the free-flowing category.

The operations in certain stages of preparation and packaging evidently may vary widely among products and so must be treated individually for each product. Other operating stages, however, are relatively uniform in the types and amounts of inputs required among the different products, or the operations involved are so similar that group analysis is both possible and expedient. The stages susceptible to group analysis--here called general operating stages--include casing, variable water requirements, freezing and first month's storage, and fork-truck transportation. Similarly, costs of management, office and bookkeeping, plant buildings, and other overhead or general cost components are relatively uniform among the vegetables considered and may be presented for all products as a group rather than on an individual product basis.

In line with the above considerations, Part III is presented in three sections:

Section 1 comprises the analysis of general cost components and operating stages that are relatively uniform among the different products considered. Planning cost equations representing total annual costs of these general categories are then aggregated and identified for reuse in subsequent analyses.

Section 2 presents detailed syntheses of crew and equipment requirements and costs for the preparation and packaging stages involved in processing each of the six vegetables included in the study. Planning cost equations relating total annual costs of these stages to capacity output rate, length of operating season, style of container, form of pack-out, and other conditions of plant

operation are also given in this section. These planning cost equations are then combined with those developed in Section 1 to provide a basis for estimating total annual costs for plants specialized in processing each of the different vegetables considered.

Section 3 brings together the cost relationships developed in the preceding sections and uses them to demonstrate the effect of plant size, length of season, and other variables on total and average planning costs.

The effects of variations in the more important variables that affect in-plant processing costs will be considered specifically. Fixed values are taken for certain other factors considered unlikely to vary enough under ordinary circumstances to have a significant effect on the cost estimates obtained. Specifications relating to such factors are summarized below.

1. Plant size is defined in terms of "capacity output rate."1/ In plants processing broccoli, Brussels sprouts, snap beans, and spinach, specific consideration is given to 10 different plant capacities varying in 2,000-pound increments over the range 2,000 to 20,000 pounds per hour; in lima bean and green pea plants, 6 different plant capacities varying in 5,000-pound increments over the range 5,000 to 30,000 pounds per hour are considered.

2. Separate packaging and casing equipment and facilities are provided for each container style and each form of output (whole, sliced, or chopped) with capacity for handling the entire plant output in any single given form or container style. This provision provides maximum output flexibility in the packaging and casing operations.

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1/ Operations in specialized plants are organized in a series of operating stages which, as an integrated aggregate, comprise the plant. Consequently, the capacity output rates of plants synthesized in this study are not the theoretical or ideal capacity rates of a single stage but are those rates that can be achieved and maintained in an integrated plant operation organized to operate with a minimum unavoidable delay. For any particular plant, this implies operation at a constant rate of output that minimizes the average total unit cost of operation. Although the costs developed in this study are based on the assumption of constant rates of output, the plants are designed with flexibility so as to operate efficiently over a range of output rates so that minor deviations from the assumed rates have no significant effect on the cost relationships obtained. Large deviations around the specified output rates are usually of short duration--usually a few days at the beginning and end of the season--and are relatively unimportant in their effect on total season costs or on long-run planning decisions.

3. Straight-time wage rates as specified in the 1960 collective bargaining agreement between frozen food processors and the California State Council of Cannery Unions are used in the estimation of plant labor costs. The wage rates are increased 6 percent to account for employer payroll contributions for social security and other benefits.

4. Buildings, management, freezing and first month's storage, office and bookkeeping, variable water inputs, casing, and other general stage and cost components are considered uniform among the different products.

These specifications apply to operations and costs for in-plant or door-to-door aspects of frozen vegetable plants. A complete cost study would require analysis of raw product and assembly, repackaging, selling, and transportation to markets as well as operating costs of maintaining working capital.

Tables that present crew and equipment requirements and some of the more specific cost estimates are provided in the supplement.1/ The data given in these tables are a synthesis based on carefully developed standards and requirements as applied to the processes and stages in processing the vegetables considered and should be consulted by those interested in the more technical aspects of plant design and organization.

1. General Cost Components and Operating Stages

General cost components and operating stages are relatively uniform in the amounts and types of inputs required or the operations are so similar for the different vegetables that the analysis may be conveniently presented for all products as a group rather than on an individual product basis. Planning cost equations representing total annual costs of these components and stages will be combined with those of preparation and packaging stages developed in Section 2 to give planning cost equations for plants processing each of the six vegetables considered on a single-product basis.

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1/ Pages 168 to 198.

General Cost Components

General cost components include management and general labor costs, office and bookkeeping costs, building costs, and miscellaneous equipment and costs.

Management and General Labor Costs

Management costs include the salaries of plant managers and executives. Costs of these inputs are probably the most difficult to estimate of any of the inputs involved in processing vegetables for freezing. The chief source of data is plant records, which are not always available to a research worker. Management is not of uniform quality among different firms, and salaries often are related to the net profit position of the firm (bonuses and dividends) and consequently do not reflect long-run salary levels. The multiple nature of the duties of management personnel also makes difficult the separation of the management costs related to selling and production.

In developing costs of plant management and general labor for this study, use is made of accounting record data made available by cooperating plants, direct observation of actual plant operations, and data from interviews with management personnel.1/ While cost estimates obtained from the different sources vary widely, they suggest that management and general labor costs are of about the same magnitude in relation to plant capacity regardless of product and are so treated in the analysis.

Estimated hourly requirements and costs for general labor and annual expense for management in plants of different size are given in Table 2. These data are the basis of the expression for total annual costs of management and general labor in relation to size of plant and length of operating season given in the planning cost equation:

$$TSC = \$4,040 + \$1,944R + \$3.867H + \$2.274RH, \tag{1}$$

where

TSC = total annual costs, in dollars, of management and general labor in processing any of the six frozen vegetables considered.

R = plant capacity in 1,000 pounds per hour.

H = number of hours operated annually.

1/ The general labor category includes direct line supervisors, such as sub-foremen and foreladies, and workers required in quality control, clean-up, and manual supply jobs.

TABLE 2

Frozen Vegetable Plants--Management and General Labor Expenses: Estimated Requirements and Costs
California, 1960

Rates of output a/	General labor requirements b/									Total hourly wages	Total management salaries per year c/
	Line foreman	Wrapper man	Cleanup	Fore-ladies	Assist-ant fore-ladies	Quality control	Utility	Tally	Total		
pounds per hour	number of workers									dollars	
2,000	1	1	1	1	d/		1		5	10.85	8,800
4,000	1	1	1	1			1		5	10.85	8,800
6,000	1	1	2	1	1	1	1		8	16.50	12,000
8,000	1	2	2	1	1	1	2		10	22.49	19,000
10,000	1	2	2	1	1	2	2	1	12	24.59	28,200
12,000	2	2	2	2	2	2	2	1	15	31.22	28,200
14,000	2	3	3	2	2	2	3	1	18	39.32	36,000
16,000	2	3	3	2	2	3	3	1	19	41.09	36,500
18,000	2	3	3	2	4	3	3	1	21	44.97	37,500
20,000	3	3	3	2	4	3	3	1	22	47.56	38,100

a/ Pack-out basis.

b/ Estimated worker requirements and wage rates based on plant record data, interviews, and direct observation. Hourly wage rates: Line foreman--$2.59; wrapper man--$2.28; cleanup, assistant foreladies, and utility--$1.94; foreladies (chief)--$2.10; quality control man--$2.10; and quality control girls and tally--$1.77.

c/ Estimated requirements and salaries based on plant record data and interviews. Includes general manager; general foreman; and general, maintenance, shift, and field superintendents. Portion of salaries attributable to sales activities is excluded.

d/ Blanks indicate does not apply.

Office and Bookkeeping Costs

The office and bookkeeping cost component includes the salaries of the office and personnel manager and the accountant and wages of clerical workers. This component does not include salaries of sales officers or other sales expenses.

Cost estimates for this category, shown in Table 3, are drawn from an analysis of accounting data in plants cooperating in this and other studies. Inputs and costs of this component are treated as uniform among the products, as the analysis of available accounting data indicated this to be appropriate. Total annual costs, in relation to rate of plant output and length of operating season, are represented by the following equation:1/

$$TSC = \$3,580 + \$1,100R + \$1.051H + \$1.141RH. \qquad (2)$$

Miscellaneous Equipment and Costs

Many equipment items such as repair, fabricating, laboratory, and housekeeping equipment are not assignable to a particular operating stage and are considered a part of general plant overhead. These requirements and costs are grouped together and summarized in Table 4. Total season costs of these equipment and expense items, related to plant output and length of operating season, are represented in equation (3) below. Estimation of these costs is based on an annual fixed charge of 16.5 percent of the equipment replacement cost and a variable repair expense of 0.5 percent of replacement cost per 100 hours of operation.

$$TSC = \$857 + \$75R + \$0.260H + \$0.023RH \qquad (3)$$

Building, Electrical, and Water Systems Costs

Building.2/--Building costs in this study are based on engineering estimates of replacement costs for plants of concrete sidewall construction with

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1/ Where TSC is total annual office and bookkeeping costs, in dollars, in processing any of the six frozen vegetables considered, and the variables R and H are as defined previously.

2/ Material on building costs draws heavily from Sammet, op. cit., and L. L. Sammet and I. F. Davis, Efficiency in Fruit Marketing: Building and Equipment Costs, Apple and Pear Packing, University of California, Giannini Foundation Mimeographed Report No. 141 (Berkeley, 1952), 38p.

TABLE 3

Frozen Vegetable Plants--Office and Bookkeeping Expenses: Estimated Requirements and Costs
California, 1960

Rates of output[a]	Seasonal administrative employees[b]										Total hourly wages	Total salaries per year[c]
	Payroll clerk	Cost clerk	Typist clerk	Timekeeper	Supply clerk	Personnel clerk	Custodian	Night watchman	Switchboard	Total		
pounds per hour	number of workers										dollars	
2,000	1	d/	1							2	3.79	5,900
4,000	1		1				1			3	5.73	5,900
6,000	1		1				1	1		4	7.67	7,700
8,000	1		1				1	1		4	7.67	14,900
10,000	1	1	1	1			1	1	1	7	11.55	20,900
12,000	1	1	1	1		1	1	2	1	9	17.03	22,100
14,000	1	1	1	1	1	1	1	2	1	10	18.80	22,100
16,000	1	1	2	1	1	1	1	2	1	11	20.65	22,100
18,000	1	1	2	1	1	1	1	2	1	11	20.65	22,100
20,000	1	1	3	1	1	1	1	2	1	12	22.50	23,100

a/ Pack-out basis.

b/ Estimated worker requirements and wage rates based on plant record data, interviews, and direct observation. Hourly wage rates: Payroll clerk, cost clerk, timekeeper, personnel clerk, custodian, and night watchman--$1.94; and typist clerk, supply clerk, and switchboard operator--$1.77.

c/ Estimated requirements and salaries based on plant record data and interviews. Includes office manager, accountant, personnel officer, and permanent clerical personnel. Portion of salaries attributable to sales activities is excluded.

d/ Blanks indicate does not apply.

TABLE 4

Frozen Vegetable Plants: Estimated Replacement Costs of Miscellaneous Tools and Equipment for Three Sizes of Plants California, 1960

Equipment items	Plant capacity		
	5,000 pounds per hour	15,000 pounds per hour	30,000 pounds per hour
	dollars		
Electric welding assembly	303	806	1,006
Cleaner, steam	965	1,930	2,895
Drill press	160	180	180
Hand drill, electric	80	160	240
Band saw	80	120	180
Grinder	68	68	68
Compressor and gun	190	190	190
Vise, portable	50	50	100
Vise, bench	125	125	250
Vise, pipe	50	50	100
Tools, sheet metal	310	310	620
Hoists, 1/4 to 1-1/2 tons	168	250	504
Pipe cutters, threaders, and taps	105	105	110
Pipe and sheet metal racks	200	800	1,000
Hand tools, miscellaneous	100	200	300
Repair parts, miscellaneous	200	600	1,200
Laboratory equipment (scales, blenders, etc.)	873	1,000	1,200
Sewage assembly (screen, tank, conveyor, etc.)	2,200	3,200	5,600
Hand truck	400	800	1,200
Belt stitcher and clamps	35	70	70
Lathe, metal working	469	750	1,040
Miscellaneous	250	500	750
Total	7,381	12,264	18,803

clear height to roof trusses of 18 feet. In general, the estimating procedure involves: (1) determination of floor space requirements in a series of efficiently organized plants of different capacity output rates and (2) estimation of construction costs for each building in the series by applying current prices to the quantities of construction labor and materials required for each structure.

Floor space requirements for well-organized plants of various capacities were developed from an analysis of floor plans of cooperating plants. Space is included for processing, temporary raw product storage, packing materials storage, boiler room, repair shop, rest rooms, and offices; but space for freezing and cold-storage facilities is not included. Space requirements in terms of total roofed area for plants of three different capacities are given in Table 5. These requirements, although specifically related to requirements of lima bean processing, closely approximate the space requirements of plants processing broccoli, Brussels sprouts, green peas, snap beans, and spinach. The estimates given in Table 5 provide a basis for a general expression of space required in relation to plant capacity as follows: $A = 5{,}000 + 1{,}005R$, where A is the total roofed area of the building in square feet, excluding freezing and cold-storage facilities, and R is plant capacity in 1,000 pounds per hour. Estimated construction costs are also given in Table 5. These costs provide the basis for a generalized expression showing total building investment in relation to plant size as measured by capacity output rates:

$$C_B = \$24{,}930 + \$3{,}140R, \qquad (4)$$

where

C_B = building investment costs in dollars.

R = plant capacity in 1,000 pounds per hour.

An annual fixed charge of 8.9 percent of replacement cost is applied to the above equation to estimate the annual fixed charge for depreciation, taxes, insurance, interest on investment, and fixed repairs.1/

$$TFC_B = \$2{,}219 + \$280R \qquad (5)$$

1/ These charges include depreciation, 2.5 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent; and repairs, 1.8 percent, for a total of 8.9 percent.

TABLE 5

Frozen Vegetable Plants: Estimated Construction Cost of Concrete Wall and Floor (Ground Level) in Relation to Size of Building California, 1960[a]

	Unit	Unit cost	Total quantity[b]			Total cost		
			Plant A	Plant B	Plant C	Plant A	Plant B	Plant C
		dollars				thousand dollars		
Roofed area								
Grading	thousand square feet	20	15.0	25.2	35.1	0.3	0.5	0.7
Floor	thousand square feet	449	15.0	25.2	35.1	6.7	11.3	15.8
Walls								
Exterior	thousand square feet	1,723	8.2	10.1	11.9	14.1	17.4	20.5
Interior	thousand square feet	618	1.0	1.6	2.4	0.6	1.0	1.5
Ceiling	thousand square feet	395	0.6	1.7	2.7	0.2	0.7	1.1
Roof and frame	thousand square feet	1,105	15.0	25.2	35.1	16.6	27.8	38.8
Doors								
Swing	each	74	6.0	6.0	8.0	0.4	0.4	0.6
Overhead	each	247	4.0	6.0	8.0	1.0	1.5	2.0
Windows	each	39	4.0	6.0	9.0	0.2	0.2	0.4
Heating	each	100	1.0	1.0	2.0	0.1	0.1	0.2
Ventilation	each	100	2.0	4.0	8.0	0.2	0.4	0.8
Total						40.4	61.3	82.4
Paving and siding								
Railroad siding	lineal feet	10	200.0	300.0	450.0	2.0	3.0	4.5
Paving	thousand square feet	499	7.8	12.0	20.7	3.9	6.0	10.3
Total						5.9	9.0	14.8
Total direct cost						46.3	70.3	97.2
Contingencies						2.3	3.5	4.9
Architectural and engineering fees						0.9	1.4	1.9
Contractor's overhead and profit						7.4	11.2	15.6
Total cost						56.9	86.4	119.6

a/ Excludes freezing and cold-storage facilities, electrical wiring, and water piping.

b/ Quantities of each construction unit estimated from space requirements of plants of three different capacities. Plant A is designed for a maximum hourly capacity of 10,000 pounds pack-out; Plant B, 20,000 pounds; and Plant C, 30,000 pounds.

Source: L. L. Sammet, "Economic and Engineering Factors in Agricultural Processing Plant Design" (unpublished Ph.D. dissertation, Department of Agricultural Economics, University of California, 1958), 434p.

Electrical Wiring.--Processing plants of identical floor area may vary widely in electrical power requirements because of differences in the power inputs of different types of equipment. For this reason, investment cost for electrical wiring is not included in the building cost estimates developed above. Variable costs of electrical inputs are included in the operating stages to which they apply (Part III, Section 2).

Costs of electrical wiring systems in this analysis are based on engineering estimates of replacement costs. The initial step in the estimating procedure is to determine power wiring and illumination requirements for a series of well-organized plants of different capacities. This involves drawing power and light circuits showing the number and distribution of motors, light fixtures, and switchboards, together with motor horsepower ratings and wattage requirements for illumination. The data thus derived are the basis for estimating the quantities and types of equipment needed for each installation.

Costs of installation and materials were then estimated by applying current prices to the quantities of labor and materials required for electrical power distribution in each size of plant considered. The prices used in the development of labor and materials costs, including charges covering contingencies, profits, and fees, were obtained from electrical contractors. Investment costs of electrical power distribution systems so developed and related to plant capacity output rates are given in the generalized planning cost equation:

$$C_E = \$3,450 + \$171R, \qquad (6)$$

where

C_E = investment costs, in dollars, of electrical power distribution.

R = plant capacity in 1,000 pounds per hour.

An annual fixed charge of 8.9 percent of replacement cost to cover depreciation, taxes, insurance, repairs, and interest is applied to equation (6). The result is:

$$TFC_E = \$307 + \$15R\,. \qquad (7)$$

Water Piping.--The quantity of water delivered through the piping system of a plant depends on such factors as gauge pressure at the source of the plant water intake; diameter, length, and age of piping; and number, size, types, and usage of orifices and valves.

Estimation of replacement costs of plant water supply systems parallels the procedure used in the estimation of electric power wiring. This involved the preparation of piping layouts showing the number and distribution of equipment items, flumes, pumps, and personal service facilities together with estimated water-use rates. The sizes and quantities of industrial piping needed were estimated from these layouts. Costs of installation and materials were then estimated by applying current prices to the quantities of labor and materials needed in each size of plant considered. The investment costs so estimated were then related to plant capacity output rates. A generalized expression of investment costs of water supply systems in relation to plant capacity output rates is:

$$C_W = \$2{,}300 + \$460R, \tag{8}$$

where

C_W = investment costs, in dollars, of a water supply system.

R = plant capacity in 1,000 pounds per hour.

The annual fixed charge of in-plant water distribution systems is obtained by applying an annual charge of 8.9 percent to equation (8). This includes the same rates for depreciation, taxes, insurance, interest, and repairs applied to buildings and electrical power systems. Annual charges based on this percentage are:

$$TFC_W = \$205 + \$41R. \tag{9}$$

Summary.--Total costs in these categories are the sum of the costs represented by the above planning cost equations. The totals--including investment costs and the corresponding annual fixed charges--are given in the equations:

$$C_B + C_E + C_W = \$30{,}680 + \$3{,}771R \text{ (investment costs)} \tag{10}$$

$$TFC_B + TFC_E + TFC_W = \$2{,}731 + \$336R \text{ (annual fixed charges)} \tag{11}$$

General Operating Stages

General operating stages include casing, freezing and first month's storage, variable water requirements, and fork-truck transportation. Like the general cost components presented earlier, the types and amounts of inputs required for these stages are relatively uniform or the operations

involved are so similar that the analysis for each stage may be applied to the entire group of vegetables considered.

Casing Operations and Costs

The principal variations among casing methods involve the degree of mechanization associated with the case-fill and case-seal operations and the type of freezing process used. In California, all observed plants used either or both of two methods for freezing vegetables--tray-tunnel or plate-freeze.1/

Carton casing methods are classified by the degree of mechanization observed. These include: Method A--manual fill and seal; Method B--manual fill, machine seal; Method C--machine fill and seal; and Method D--machine fill, manual seal. With Methods A and B, equipment requirements and layouts are equally adaptable for retail or institutional carton casing. The machine case-filling equipment used with Methods C and D is adapted for retail casing only, and additional facilities are required for manual fill of cases of institutional cartons. A detailed comparative cost analysis in an earlier study indicated that Method B was the least-cost method for both retail and institutional styles over all ranges of output rates and lengths of operating season considered.2/

Crew requirements and estimated equipment requirements are given in supplement Tables S-1 and S-2, respectively. These data are the basis for the estimated costs of labor and other variable inputs as well as the investment cost and annual fixed charges for equipment that are given in Table 6.

Estimated Variable Costs.--Estimation of the annual variable costs of the casing stage is complicated because output of this stage is not uniquely defined in terms of a given style of container. Consequently, annual variable costs for this stage vary not only with hours operated per season and hourly capacity rates of plant output but also with the proportions packed in the two container sizes. The relationship between hourly variable costs

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1/ For a description of the various methods used in freezing operations, see Reed, op. cit.

2/ Reed, Economic Efficiency in Assembly and Processing Lima Beans for Freezing, University of California, Giannini Foundation Mimeographed Report No. 219 (Berkeley, 1959), 106p.

TABLE 6

Frozen Vegatable Plants--Casing Stages: Replacement Costs, Annual Fixed Charges, and Variable Costs for Casing Tray-Frozen Vagetablas in Relation to Selected Rates of Output, Styles of Pack, and Methods Used California, 1960

Rates of output a/	Fixed costs, retail and institutional styles b/						Variable costs							
	Replacement costs			Annual fixed charges			Retail style				Institutional style			
	Equipment c/	Belting d/	Total	Equipment e/	Belting f/	Total	Labor g/	Power, repairs, and miscellaneous h/	Cases i/	Total	Labor g/	Power, repairs, and miscellaneous h/	Cases j/	Total
pounds per hour	dollars													
	Method A--Manual fill and seal													
2,000	935	k/	935	154		154	9.19	0.73	12.06	21.98	7.42	0.38	7.17	14.97
4,000	1,030		1,030	170		170	10.96	0.91	24.12	35.99	7.42	0.57	14.34	22.33
6,000	1,705		1,705	281		281	18.38	1.31	36.18	55.87	10.96	0.76	21.51	33.28
8,000	1,800		1,800	297		297	20.15	1.72	48.24	70.11	12.73	0.95	28.68	42.36
10,000	1,895		1,895	313		313	25.63	2.13	60.30	88.06	16.61	1.14	35.85	53.60
12,000	2,630		2,630	434		434	31.11	2.56	72.36	106.03	18.38	1.37	43.02	62.77
14,000	2,725		2,725	450		450	34.82	2.99	84.42	122.23	20.15	1.60	50.19	71.94
16,000	3,425		3,425	565		565	40.30	3.42	96.48	140.20	21.92	1.83	57.36	81.11
18,000	3,570		3,570	589		589	42.07	3.85	108.54	154.46	25.80	2.06	64.53	92.39
20,000	3,665		3,665	605		605	45.78	4.27	120.60	170.65	27.57	2.28	71.70	101.55
25,000	4,495		4,495	742		742	56.74	5.31	150.75	212.80	32.88	2.82	89.67	125.37
30,000	5,360		5,360	884		884	65.93	6.36	180.90	253.19	38.53	3.38	107.54	149.45
	Method B--Manual fill, machine seal													
2,000	5,562	39	5,601	918	10	928	7.42	0.71	12.06	20.19	7.42	0.32	7.17	14.91
4,000	5,657	39	5,696	933	10	943	9.19	1.00	24.12	34.31	7.42	0.46	14.34	22.22
6,000	5,657	39	5,696	933	10	943	11.13	1.29	36.18	46.80	7.42	0.60	21.51	29.53
8,000	6,586	39	6,625	1,087	10	1,097	14.84	1.58	48.24	64.66	9.19	0.74	28.68	38.61
10,000	6,681	39	6,720	1,102	10	1,112	18.38	1.86	60.30	80.54	11.13	0.88	35.85	47.86
12,000	6,741	39	6,780	1,112	10	1,122	20.32	2.23	72.36	94.91	11.13	1.06	43.02	55.21
14,000	7,464	39	7,503	1,232	10	1,242	22.09	2.60	84.42	109.11	14.84	1.24	50.19	66.27
16,000	7,464	39	7,503	1,232	10	1,242	27.74	2.97	96.48	127.19	16.61	1.42	57.36	75.39
18,000	12,308	78	12,386	2,031	20	2,051	29.51	3.34	108.54	141.39	18.55	1.60	64.53	84.68
20,000	13,237	78	13,315	2,184	20	2,204	31.28	3.73	120.60	155.61	20.32	1.78	71.70	93.80
25,000	14,180	78	14,258	2,340	20	2,360	38.70	4.51	150.75	193.96	22.09	2.20	89.67	113.96
30,000	14,838	78	14,916	2,448	20	2,468	46.12	5.30	180.90	232.32	27.74	2.62	107.54	137.90
	Method C--Machine fill and seal													
2,000	8,471	120	8,591	1,398	30	1,428	9.19	0.80	12.06	22.05	7.42	0.32	7.17	14.91
4,000	8,471	120	8,591	1,398	30	1,428	9.19	1.15	24.12	34.46	7.42	0.46	14.34	22.22
6,000	8,471	120	8,591	1,398	30	1,428	11.13	1.50	36.18	48.81	7.42	0.60	21.51	29.53
8,000	9,305	120	9,425	1,535	30	1,565	13.07	1.85	48.24	63.16	9.19	0.74	28.68	38.61
10,000	13,207	290	13,490	2,179	73	2,252	18.38	2.20	60.30	80.88	11.13	0.88	35.85	47.86
12,000	13,267	290	13,557	2,189	73	2,262	20.32	2.60	72.36	95.28	11.13	1.06	43.02	55.21
14,000	13,895	290	14,185	2,293	73	2,366	20.32	3.00	84.42	107.74	14.84	1.24	50.19	66.27
16,000	13,895	290	14,185	2,293	73	2,366	24.20	3.40	96.48	124.08	16.61	1.42	57.36	75.39
18,000	21,648	411	22,059	3,572	103	3,675	29.51	3.80	108.54	141.85	18.55	1.60	64.53	84.68
20,000	22,482	411	22,893	3,710	103	3,813	29.51	4.19	120.60	154.30	20.32	1.78	71.70	93.80
25,000	23,170	411	23,581	3,823	103	3,926	36.93	4.99	150.75	192.67	22.09	2.20	89.67	113.96
30,000	27,700	580	28,280	4,571	145	4,716	42.58	5.99	180.90	229.47	27.74	2.62	107.54	137.90
	Method D--Machine fill, manual seal													
2,000	3,854	86	3,940	636	22	658	10.96	0.82	12.06	23.84	7.42	0.38	7.17	14.97
4,000	3,854	86	3,940	636	22	658	10.96	1.24	24.12	36.32	7.42	0.57	14.34	22.33
6,000	4,529	86	4,615	747	22	769	18.38	1.66	36.18	56.22	10.96	0.76	21.51	33.28
8,000	4,529	86	4,615	747	22	769	18.38	2.08	48.24	68.70	12.73	0.95	28.68	42.36
10,000	7,643	172	7,765	1,253	43	1,296	25.63	2.50	60.30	88.43	16.61	1.14	35.85	53.60
12,000	8,328	172	8,500	1,374	43	1,417	31.11	2.96	72.36	106.43	18.38	1.37	43.02	62.77
14,000	8,328	172	8,500	1,374	43	1,417	33.05	3.42	84.42	120.89	20.15	1.60	50.19	71.94
16,000	9,028	172	9,200	1,490	43	1,533	36.76	3.88	96.48	137.12	21.92	1.83	57.36	81.11
18,000	12,092	258	12,350	1,995	65	2,060	42.07	4.34	108.54	154.95	25.80	2.06	64.53	92.39
20,000	12,092	258	12,350	1,995	65	2,060	44.01	4.80	120.60	169.41	27.57	2.28	71.70	101.55
25,000	12,827	258	13,085	2,116	65	2,181	53.20	5.88	150.75	209.83	32.88	2.82	89.67	125.37
30,000	16,566	344	16,910	2,733	86	2,819	62.39	7.10	180.90	250.39	38.53	3.38	107.54	149.45

a/ Pack-out basis.

b/ Equipment is adapted for casing both retail and institutional styles.

c/ Costs of replacing all equipment. For equipment requirements, specifications, and unit prices, see Table S-2 the supplement.

d/ Calculated by the following equation: $C_b = \$0.41WL + \$0.28NW$, where W is the width of belt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights.

e/ Calculated as 16.5 percent of equipment replacement costs, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

f/ Calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on investment, 3 percent.

g/ Calculated from crew requirements and wage rates given in Table S-1 of the supplement.

h/ Electric power estimated at 2.5 cents per horsepower hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies. Miscellaneous includes glue estimated at $75 per 100 gallons and wire at $28 per 100 pounds.

i/ Costs based on 24/10-ounce cases, four panels, two colors, estimated at $90 per 1,000 cases, 0.5 percent waste allowance.

j/ Costs based on 12/2½-pound cases, four panels, two colors, estimated at $107 per 1,000 cases, 0.5 percent waste allowance.

k/ Blanks indicate does not apply.

of casing each of the two styles and hourly volumes of output is shown in Figure 4. Here, the relation of hourly variable cost to hourly volume is approximately linear and through the origin for both retail and institutional styles. This means that unit cost per pound for casing each style of container is constant at all capacity rates of casing considered and is independent of the scale of operations. Average unit costs based on the points in Figure 4 are \$7.817 and \$4.655 per 1,000 pounds cased in retail and institutional styles, respectively. Total variable casing costs per season are estimated by applying these unit costs to the total season volume packed in each style. Annual variable casing costs, calculated on this basis, are given by the equation:

$$TVC = \$7.817 R_r H_r + \$4.655 R_i H_i, \tag{12}$$

where

TVC = total annual variable costs, in dollars, of casing vegetables.

H_r = number of hours operated, retail carton casing.

H_i = number of hours operated, institutional carton casing.

R_r = rate of casing retail cartons, in 1,000 pounds per hour.

R_i = rate of casing institutional cartons, in 1,000 pounds per hour.

$R_r H_r$ = total season volume, retail cases, in 1,000 pounds per hour.

$R_i H_i$ = total season volume, institutional cases, in 1,000 pounds per hour.

The above planning cost equation may be used to estimate annual variable casing costs for any proportion of total season volume that is packed in retail or institutional styles.

Annual Fixed Charges.--The annual fixed charges given in Table 6 are used to develop the following generalized expression showing how these charges vary with size of plant as measured by capacity output rate.

$$TFC = \$480 + \$67R \tag{13}$$

Total Annual Casing Costs.--Total annual casing costs for any given plant capacity and length of operating season are the sum of the corresponding annual fixed costs and variable cost components. The planning cost equation for plants casing any combination of retail and institutional cartons is:

$$TSC = \$480 + \$67R + \$7.817 R_r H_r + \$4.655 R_i H_i . \tag{14}$$

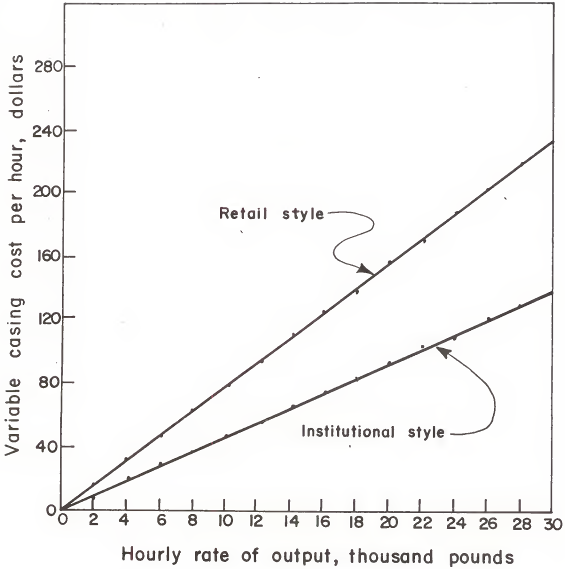

Figure 4. Relation of Hourly Variable Casing Costs to Hourly Rates of Output in Vegetable Freezing Plants Equipped to Case Retail and Institutional Cartons, California, 1960.

Variable Water Inputs and Costs

Variable water inputs, like electric power and fuel requirements, are primarily associated with particular operating stages of plant operation. For convenience, however, the estimated average requirements and variable costs of water for the plant as a whole are summarized in this section. Water usage varies among the different vegetables processed, but when converted to costs the differences are slight. Consequently, the inputs and costs given in Table 7 are averages of the separate requirements of the particular vegetables studied. Estimated rates of water usage with the types and amounts of equipment used in the various operating stages are developed from data obtained from equipment manufacturers, processors, contractors, and from studies of equipment operating characteristics in plants cooperating in the research.

Estimated water costs--also given in Table 7--are obtained by applying average public utility industrial water rates to the estimated water requirements.[1/] Typical rates involve a fixed annual standby charge and an average unit price of 13 cents per 100 cubic feet (approximately 750 gallons) of water used. The cost data in Table 7 are the basis for estimated total water costs given in the planning cost equation:

$$TSC_W = \$166 + \$15R + \$0.187H + \$0.538RH \,. \qquad (15)$$

Freezing and First Month's Storage

Costs associated with storage beyond the first month are classified as selling expense and are not considered in this study. Freezing and first month's storage costs, however, are treated as an operating expense. These costs are related to the type of product packed, style of container, storage or handling methods used, operating and storage capacity, and length of operating season. Development of precise relationships among these variables requires a detailed economic-engineering analysis of freezing and storage operations. Such results are not available, and the costs used in this study are based on data obtained from plant records. Accordingly, total freezing and first month's storage costs are estimated on the basis of

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1/ The development of pumping costs for privately owned wells was not attempted, as the depth to static ground water levels varies widely within and among processing areas.

TABLE 7

Frozen Vegetable Plants: Estimated Water Inputs and Variable and Standby Costs in Relation to Selected Rates of Output California, 1960

Rates of output	Water inputs, each product a/				Variable and standby costs	
	Washing and cleaning	Blanching and boilers	Other b/	Total	Hourly variable costs c/	Annual standby charges d/
pounds per hour	thousand gallons per hour				dollars	
5,000	5.3	5.5	5.0	15.8	2.74	180
10,000	15.5	7.9	8.3	31.7	5.50	300
15,000	18.8	15.2	13.9	47.9	8.31	400
20,000	28.1	19.4	17.2	64.7	11.22	400
25,000	35.0	25.1	21.7	81.8	14.18	600
30,000	39.6	29.0	25.1	93.7	16.24	600

a/ Includes estimated water inputs for each of the following vegetables: lima beans, snap beans, broccoli, Brussels sprouts, green peas, and spinach. For individual equipment items, see specific stage analyses of the various products (Part III, Section 2) and corresponding tables in the supplement.

b/ Includes cooling, distribution, laboratory, and personal service facilities.

c/ Based on average Public Utilities Commission rates--approximately 13 cents per 100 cubic feet (750 gallons).

d/ Standby charge for meter service, etc.

annual volume and a unit freezing and storage cost representative of rates paid to commercial warehouses for this service. Costs estimated on this basis are given in the planning cost equation:

$$TSC_F = \$8.30RH. \qquad (16)$$

As about 70 percent of the plants observed rely on commercial cold-storage companies for freezing and storage operations, the costs estimated by equation (16) are considered representative of the costs experienced by most California plants.

Fork-Truck Transportation

Highly integrated transportation links such as pipe, flume, belt, and other types of conveyors used in maintaining the flow of materials within and among operating stages are included as components of the specific plant operating stages. As the various transportation activities involving the use of fork trucks are often performed by the same equipment and crew, they are combined in this section to form a single operating stage.

Net time requirements for the fork-truck jobs observed were measured by time and production studies in frozen vegetable plants and fresh fruit packinghouses.[1/] Total net time per round trip has two components--"turn around" and transit time. Turn-around activities involve operations common to each trip such as engaging the load and set off. Transit time is the time required to move loaded pallets or bins to the delivery point and return, unloaded, to the pick-up point. Net time requirements calculated on this basis are summarized in Table S-3 of the supplement for each of the six vegetables in this study.

Production standards for the fork-truck operations specified, including allowances for miscellaneous trucking jobs and unavoidable delays, are given in the last entry of Table S-3. A large part of the work performed in miscellaneous trucking jobs, including the transportation of processing and packaging materials, may be accomplished between shifts or during other periods of plant inactivity. However, this portion of the transportation load

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1/ For more details regarding measurement procedure, refer to Sammet, Efficiency in Fruit Marketing: In-Plant Transportation Costs as Related to Materials Handling Methods--Apple and Pear Packing, University of California, Giannini Foundation Mimeographed Report No. 142 (Berkeley, 1953), 57p.

represents a small percentage of the time required in the overall transportation operation, and general observations coupled with analyses of plant equipment inventories suggest that the procedure used gives good estimates of fork-truck requirements during peak load periods. The studies indicate that unavoidable delays such as scheduled rest periods, unproductive time due to contingencies, and personal time vary in particular plants from 15 to 40 percent of total trucking time. Twenty percent is used as a practical minimum.

Among the products received and otherwise handled in bins, Table S-3 of the supplement shows that fork-truck requirements for the initial receiving and dumping operations are approximately the same. Brussels sprouts and snap beans are rehandled in the size-grading and snipping operations, respectively, and consequently require more transportation than broccoli. As lima beans, green peas, and spinach are received in bulk containers--either dump trucks or trailers or both--fork-truck transportation inputs in plants handling these commodities are relatively small.

Variable costs, equipment replacement costs, and annual fixed charges are calculated by applying appropriate cost rates and charges to the equipment and crew requirements derived from the standards given in Table S-3. These costs are summarized in Table 8 and provide the basis for the development of the following planning equations for plants handling each of the products specified on a specialized single-product basis.[1/]

Broccoli plants:

$$TSC = \$600 + \$121R + \$1.362H + \$0.398RH \qquad (17)$$

Brussels sprouts plants:

$$TSC = \$420 + \$155R + \$0.912H + \$0.493RH \qquad (18)$$

Snap bean plants:

$$TSC = \$547 + \$177R + \$1.217H + \$0.581RH \qquad (19)$$

Lima bean, green pea, and spinach plants:

$$TSC = \$700 + \$38R + \$1.521H + \$0.138RH \qquad (20)$$

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1/ Where TSC is total season costs, in dollars, of fork-truck transportation for plants processing the vegetables indicated, R is plant capacity in 1,000 pounds per hour, and H is number of hours operated per season.

TABLE 8

Frozen Vegetable Plants: Variable Costs, Replacement Costs, and Annual Fixed Charges of Fork-Truck Transportation in Relation to Selected Rates of Output
California, 1960

Rates of output a/	Broccoli					Brussels sprouts					Snap beans				
	Variable costs			Equipment replacement costs c/	Equipment annual fixed charges d/	Variable costs			Equipment replacement costs c/	Equipment annual fixed charges d/	Variable costs			Equipment replacement costs c/	Equipment annual fixed charges d/
	Operator	Repairs and fuel b/	Total			Operator	Repairs and fuel b/	Total			Operator	Repairs and fuel b/	Total		
pounds per hour	dollars														
2,000	2.28	0.21	2.49	5,775	953	2.28	0.24	2.52	5,775	953	2.28	0.31	2.59	5,775	953
4,000	2.28	0.42	2.70	5,775	953	2.28	0.48	2.76	5,775	953	2.28	0.61	2.89	5,775	953
6,000	2.28	0.63	2.91	5,775	953	2.28	0.72	3.00	5,775	953	4.56	0.92	5.48	11,550	1,906
8,000	4.56	0.86	5.42	11,550	1,906	4.56	0.96	5.52	11,550	1,906	4.56	1.22	5.78	11,550	1,906
10,000	4.56	1.07	5.63	11,550	1,906	4.56	1.20	5.76	11,550	1,906	4.56	1.53	6.09	11,550	1,906
12,000	4.56	1.28	5.84	11,550	1,906	4.56	1.44	6.00	11,550	1,906	6.84	1.83	8.67	17,325	2,859
14,000	4.56	1.50	6.06	11,550	1,906	6.84	1.67	8.51	17,325	2,859	6.84	2.14	8.98	17,325	2,859
16,000	6.84	1.71	8.55	17,325	2,859	6.84	1.92	8.76	17,325	2,859	9.12	2.45	11.57	23,100	3,812
18,000	6.84	1.92	8.76	17,325	2,859	6.84	2.16	9.00	17,325	2,859	9.12	2.75	11.87	23,100	3,812
20,000	6.84	2.14	8.98	17,325	2,859	9.12	2.40	11.52	23,100	3,812	9.12	3.06	12.18	23,100	3,812
	Lima beans					Green peas					Spinach				
2,000	2.28	0.08	2.36	5,775	953	2.28	0.08	2.36	5,775	953	2.28	0.08	2.36	5,775	953
4,000	2.28	0.17	2.45	5,775	953	2.28	0.17	2.45	5,775	953	2.28	0.17	2.45	5,775	953
6,000	2.28	0.25	2.53	5,775	953	2.28	0.25	2.53	5,775	953	2.28	0.25	2.53	5,775	953
8,000	2.28	0.33	2.61	5,775	953	2.28	0.33	2.61	5,775	953	2.28	0.33	2.61	5,775	953
10,000	2.28	0.42	2.70	5,775	953	2.28	0.42	2.70	5,775	953	2.28	0.42	2.70	5,775	953
12,000	2.28	0.50	2.78	5,775	953	2.28	0.50	2.78	5,775	953	2.28	0.50	2.78	5,775	953
14,000	2.28	0.58	2.86	5,775	953	2.28	0.58	2.86	5,775	953	2.28	0.58	2.86	5,775	953
16,000	2.28	0.67	2.95	5,775	953	2.28	0.67	2.95	5,775	953	2.28	0.67	2.95	5,775	953
18,000	2.28	0.75	3.03	5,775	953	2.28	0.75	3.03	5,775	953	2.28	0.75	3.03	5,775	953
20,000	4.56	0.83	5.39	11,550	1,906	4.56	0.83	5.39	11,550	1,906	4.56	0.83	5.39	11,550	1,906
25,000	4.56	1.04	5.60	11,550	1,906	4.56	1.04	5.60	11,550	1,906	4.56	1.04	5.60	11,550	1,906
30,000	4.56	1.25	5.81	11,550	1,906	4.56	1.25	5.81	11,550	1,906	4.56	1.25	5.81	11,550	1,906

a/ Pack-out basis.

b/ Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies. Fuel estimated at 21 cents per gallon.

c/ Fork truck, standard type, 4,000-pounds capacity, gas driven--$5,775, delivered.

d/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

Summary

Planning cost equations developed in Section 1 are brought together in Table 9. The stages and cost components[1/] for which planning cost equations have been calculated are identified in the first column of the table, and each of the remaining columns relates to the variables used in deriving them. The specific equations can be read directly from the table by applying appropriate coefficients given in the body of the table to the variables listed in the column headings. For example, the planning cost equation for the casing stage, read from the first line of the table, is: TSC = \$480 + \$67R + \$7.817R_rH_r + \$4.655R_iH_i, where TSC is total annual costs of casing retail and institutional cartons of frozen vegetables, and the variables R, R_rH_r, and R_iH_i are defined in the footnotes of the table. Planning cost equations of the specified stages and cost components are combined into totals for plants processing each product and are given in the last section of Table 9.

The cost relationships summarized in Table 9 may be combined with the planning cost equations for the preparation and packaging stages of each product to estimate total annual costs for specialized single-product plants processing each of the vegetables considered. This procedure condenses the presentation of the analyses by avoiding several repetitions of cycles of analysis given in Section 1.

2. Analysis of Specific Operating Stages and Synthesis of Total Processing Costs in Single-Product Plants

Planning cost equations representing total season costs for operating stages and cost components not significantly different among products were developed in Section 1. This section presents detailed analyses of operations and costs for the preparation and packaging stages that are specialized for each vegetable considered. Planning cost equations for these stages are then combined with those of Section 1 to give planning cost equations representing total annual costs for plants specialized in processing each vegetable studied.

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1/ These include casing, freezing and first month's storage, variable water inputs, fork-truck transportation, building costs, management and general labor costs, office and bookkeeping costs, and miscellaneous equipment and costs.

TABLE 9

Frozen Vegetable Plants: Summary of Planning Cost Equations Representing Total Annual Costs of General Operating Stages and Cost Components California, 1960

Cost category a/	Variables b/					
	Constant term	R	H	RH	R_rH_r	R_iH_i
	coefficients in dollars					
General Operating Stages						
Casing	480	67	c/		7.817	4.655
Variable water inputs	166	15	0.187	0.538		
Freezing and first month's storage				8.300		
Fork-truck transportation						
Broccoli	600	121	1.362	0.398		
Brussels sprouts	420	155	0.912	0.493		
Snap beans	547	177	1.217	0.581		
Lima beans, green peas, and spinach	700	38	1.521	0.138		
General Cost Components						
Plant investment						
Buildings	2,219	280				
Electrical wiring	307	15				
Water piping	205	41				
Total	2,731	336				
Office and bookkeeping	3,580	1,100	1.051	1.141		
Management and general labor	4,040	1,944	3.867	2.274		
Miscellaneous equipment and costs	857	75	0.260	0.023		
Total general costs for specialized plants						
Broccoli	12,454	3,658	6.727	12.674	7.817	4.655
Brussels sprouts	12,274	3,692	6.277	12.769	7.817	4.655
Snap beans	12,401	3,714	6.582	12.857	7.817	4.655
Lima beans	12,554	3,575	6.886	12.414	7.817	4.655
Green peas	12,554	3,575	6.886	12.414	7.817	4.655
Spinach	12,554	3,575	6.886	12.414	7.817	4.655

a/ For more detail, refer to discussion in text.

b/ Variables are defined as follows:

R = plant capacity in 1,000 pounds per hour, pack-out basis.

H = total number of hours operated per season.

RH = total season volume in 1,000 pounds per hour.

R_rH_r = total season volume, retail cartons, in 1,000 pounds per hour.

R_iH_i = total season volume, institutional cartons, in 1,000 pounds per hour.

c/ Blanks indicate does not apply.

The procedures used in developing costs for specialized lima bean and green pea plants are given detailed treatment. As the procedures of analysis employed for all the vegetables studied are similar, the remaining products are discussed in more summary form. Throughout the analyses there is frequent reference to the supplement to this report (pages 168 to 198), which should be consulted by those interested in more detailed study.

Frozen Lima Bean and Green Pea Plants

The principal steps in preparing and packaging lima beans and green peas for freezing are illustrated in the plant layout (Figure 5). Except for initial quality grading and manual sorting in the preparation stages, the operations are identical for both products. Similar cost analyses can therefore be made, with special study of the steps in preparation stages that require different treatments.

Lima Bean Preparation

Figure 5 shows lima bean preparation stages to include receiving, initial cleaning, and quality grading; blanching and second quality grading; and manual quality sorting. Most of the observed plants process both Fordhook and baby lima bean varieties with the same equipment. The Fordhook bean is larger than the baby lima but of equal density. In terms of beans processed, the capacities of given equipment units will therefore be larger for the baby lima as compared with the Fordhook variety. The equipment layouts and designs in this study are based on standards and requirements for the Fordhook variety in all stages except manual sorting, where they are in terms of the baby lima variety.

Receiving, Initial Cleaning, and Quality Grading.--At the plant receiving yard, the beans are emptied into receiving tanks mounted on a shaker-frame assembly.[1/] The beans feed continuously from the receiving tank to a pump intake conveyor or flume where they are pumped, dewatered, and delivered to mechanical quality graders situated on a raised platform. The quality grader separates the beans into maturity grades using the

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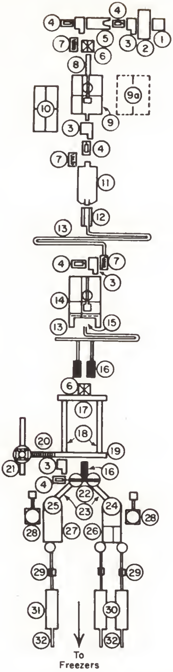
1/ For a detailed comparison of costs with bin versus bulk handling, refer to Reed, Economic Efficiency in Assembly . . . , pp. 19-26.



LEGEND

1. Dump Station
2. Receiving Tank
3. 3" Food Pump
4. Return Water Screen and Supply Tank
5. Flotation Washer
6. Pneumatic Separator
7. Dewater Reel
8. Conveyor
9. Pre-Blanch Mechanical Quality Grader

9A. Froth Cleaner Assembly (2 units) for use with Green Peas

10. Temporary Storage Hoppers
11. Hot Water Blanch Assembly
12. Rotary Washer
13. Flumes
14. Post-Blanch Mechanical Quality Grader
15. Surge Tanks
16. Dewater Shakers
17. Cross Conveyor or Flume
18. Pick Belts
19. Cross Collection Flume
20. Mesh Conveyor
21. Bulk Tray Filling Assembly
22. Accumulating Hoppers
23. Vibrator Feeders
24. Retail Fill Hopper
25. Institutional Fill Hopper
26. Retail Filler
27. Institutional Filler
28. Carton Forming Assembly
29. Carton Closer
30. Retail Carton Wrapper
31. Institutional Carton Wrapper
32. Tray off Assembly

Capacity: 5 to 6 tons per hour; approximate scale: 1/8" = 5'

Figure 5. Layout of a Specialized Frozen Lima Bean and Green Pea Line, California, 1960.

specific gravity principle. Normally, the higher quality beans continue to the blanching operation while the overflow and more mature beans are conveyed to temporary storage and iced to await further processing.

Labor requirements for these operations include attendants for receiving, cleaning and quality grading, and handling temporary storage facilities. Labor production standards for these machine-paced jobs and crew requirements in relation to selected output rates are given in Table S-4 of the supplement. Detailed equipment specifications, including types, capacities, prices per unit, and equipment requirements in relation to selected output rates are given in Table S-5 of the supplement.

Blanching and Second Quality Grading.--The blanching operation consists of heating the product with hot water or steam or a combination of both. Its primary purpose is the partial prevention of enzyme activity that produces off-flavors and discoloration. The duration of the blanching treatment depends primarily on the temperature of the water bath and the size and firmness of the beans. At the temperature usually maintained--just below boiling--an exposure time of approximately 3 minutes for baby limas and $3\frac{1}{4}$ to 4 minutes for the Fordhook variety is required. Blanching equipment and service inputs (steam and water) requirements in this analysis are developed on the basis of a 4-minute exposure time.

The beans are flumed from the initial quality grading operation over a drain or dewater belt and into the blancher (see Figure 5). The blancher consists of an outer tank that holds the blanch water through which the beans are conveyed in a perforated revolving drum or blanching reel having an inner spiral. Water is supplied at the discharge end of the unit, and two steam inlet pipes are also provided. In this study it is assumed that each blancher is equipped with a variable-speed transmission or drive and an automatic temperature-control system to permit the operator to maintain proper blanch temperatures and exposure times. Steam at 125-pounds-per-square-inch pressure is furnished by boilers fired with forced draft natural gas burners.

In most of the lima bean operations studied, provision is made for a second, or postblanch, quality grade separation. The postblanch quality grading step is required when product quality is such that initial grading cannot separate overmature and shriveled beans with enough selectivity to avoid grade losses. If the beans received are of generally high quality,

initial grading may suffice, and the postblanch grading equipment may be used as a skimmer or bypassed entirely. Provision for postblanch grading is included in the equipment layouts of lima bean plants synthesized here (Figure 5).

Labor requirements include attendants for the blanch, brine, and boiler equipment. Detailed labor and equipment requirements are given in supplement Tables S-4 and S-5, respectively.

Visual Inspection and Manual Quality Sorting.--While most overmature beans and defects are removed by mechanical brine separation and cleaning, maturity grading to a strict tolerance by these means is difficult because of small differences, in some lots, in specific gravity of green and overmature beans.1/ Consequently, quality separation by manual means is necessary for final inspection and removal of any overmature beans or defects that remain.

Beans are flumed directly from the second quality grading station to the sorting belts. These belts, with a few exceptions, are 24 inches wide and from 15 to 30 feet in length.2/ A wire-mesh dewatering belt comprises the first section of the sorting belt from which the beans are deposited on a rubber or neoprene cannery belt moving in the same direction. This arrangement results in a "cascade" effect which turns the beans over so both sides can be inspected with minimum effort by sorters stationed along the entire length of the belt, including the wire-mesh section.

The amount of sorting labor required depends on the volume of beans run per belt hour and the proportion of defects and overmature beans which must be removed. Visual inspection requires effort which cannot easily be measured in quantitative terms, and direct work measurement techniques such as work sampling, time, or production studies are inappropriate for measuring the input of sorter labor. Accounting record data showing the number of

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1/ Defects include extraneous vegetable material, pieces, shrivels, sprouts, discoloration, and blemishes. For a detailed discussion of grade determinants, refer to U. S. Agricultural Marketing Service, United States Standards for Grades of Frozen Lima Beans, Effective April 16, 1957, 1957, 6p.

2/ Sorting tables or belts vary among plants in construction characteristics, but no significant differences in replacement costs were detected. The inspection belts synthesized in this study are 24" x 25', each with an estimated capacity of 7,000 pounds per hour.

sorters in relation to volume run per belt hour and pounds of grade-out were not available in the detail required. Furthermore, the number of beans rather than their weight per belt hour and proportion of grade-out is a more relevant factor to consider in the measurement of sorting labor inputs.

Because of the limitations of direct work measurement and the difficulty of obtaining adequate plant record data, an intermediate approach was used. Direct studies were made of the sorting operation in seven plants. The procedure involved five major steps.

1. Samples of 2 pounds each were removed immediately prior to sorting.[1/] At the same time, the number of sorters employed on each inspection belt was recorded.
2. The volume of beans on each inspection belt at the time the sample was removed was estimated from the plant production tally.
3. A count was made of the total number of units in each sample. This included the total number of "green" beans in the sample as well as the number of grade-outs--overmature beans and defects.
4. "Manual grade-out percentage"--defined as the ratio of the number of beans including defects and overmature beans not meeting grade requirements to the total number of units in the sample--was computed and recorded.
5. A check was made with the U. S. Department of Agriculture or plant grade inspector to ascertain the grade and score of the finished product in each lot sampled.

The data obtained were made comparable and summarized according to volume run per belt hour, grade-out percentage, and number of sorters.[2/] These data were then separated into subgroups reflecting small intervals in grade-out percentages.[3/] For each subgroup, the number of sorters was

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1/ Approximately 300 samples were taken in each of the plants studied.

2/ On an equal weight basis, 100 Fordhook beans are, on the average, roughly equivalent to 283 baby lima beans. This conversion factor was developed from count data in the samples described above and by numerous additional samples made available through the courtesy of U. S. Department of Agriculture grade inspectors.

3/ Subgroups of manual grade-out percentages considered were: 0.5 to 1 percent, 1 to 2 percent, 2 to 4 percent, 4 to 6 percent, and 8 to 10 percent, as these percentages cover the range observed in the plants studied.

plotted against output rates per belt hour. Figure 6 shows these points for the 4 to 6 percent grade-out category.

The wide scatter of points in Figure 6 suggests underutilization of sorting labor during certain periods. This was expected, as workers idled during temporary stoppages in other parts of the plant and surplus labor provided for contingencies usually are assigned temporarily to the sorting operation even though not required by the work load there. In terms of the definition of work standards previously presented, an "efficiency standard" represents better-than-average, but not maximum, performance levels. The application of this guide to the selection of a sorting labor standard is represented in Figure 6. The solid upper line in the figure shows the <u>average</u> performance level of sorters at various rates of output per belt hour, while the dashed lower line indicates the <u>maximum</u> performance rate observed. These two reference lines define the range of rates considered in establishing the sorting standards in this analysis. The line connecting the crosses in the figure represents the sorting labor standard finally derived for this particular manual grade-out percentage subgroup. The same procedure was used for each of the categories of product quality considered. A generalized expression derived from these analyses relating the number of sorters to the rate of plant output per hour and manual grade-out percentage is summarized in the equation:1/

$$N = 5.101 + 0.892R + 0.065R\bar{p}\,, \tag{21}$$

where

N = number of sorters required.

R = plant capacity in 1,000 pounds per hour.

$\bar{p}$ = manual grade-out percentage.

For any given rate of output and manual grade-out percentage, this equation can be used to estimate the number of sorters required with efficient organization. For example, the number of sorters required for a plant operating at the rate of 10,000 pounds per hour with a manual grade-out percentage of 5 percent is: $N = 5.101 + 0.892(10) - 0.0656(10)(5) = 17.3$ sorters.

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1/ Equation (21) is fitted by graphical procedures. For details, refer to Sammet, "Economic and Engineering Factors . . . ," pp. 167-178.

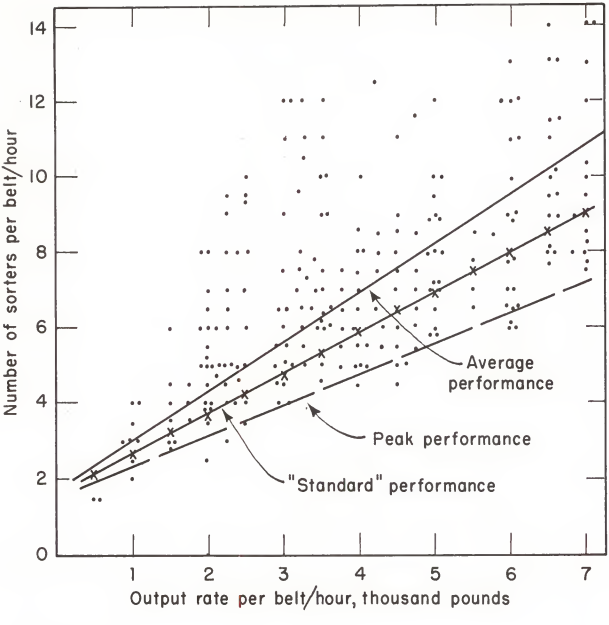

Figure 6. Sorting Labor Input Related to Output per Belt Hour and 4 to 6 Percent Grade-Out Percentage in Lima Bean Freezing Plants, California, 1960.

Eighteen sorters are required under the conditions assumed as fractional inputs are adjusted to the next whole number.[1/]

To use these relationships in forecasting sorter crew requirements, field estimates must be made of grade-out percentages. Grower "pay weight" samples may be used for this purpose. Reliable estimates of the efficiency of mechanical brine separation and cleaning equipment are also essential as a means of estimating the percentage grade-out count which must be manually removed, remembering that "percentage grade-out" refers to the percentage of overmature beans and defects on a count basis as distinguished from a weight basis. The sorting standards developed apply specifically to U. S. Grade A packs.

Total Annual Preparation Costs.--The detailed crew and equipment requirements and cost rates given in supplement Tables S-4 and S-5, respectively, provide the basis for estimating the costs of variable inputs, equipment replacement costs, and annual fixed charges for the preparation stages discussed above. These costs, in relation to selected capacity rates of output, are summarized in Table 10 and represent least-cost methods of performing the operations involved.

Total annual costs as related to selected capacity output rates and different lengths of operating season are calculated by multiplying the hourly variable costs given in Table 10 by the number of hours operated and adding the corresponding annual fixed charges. Total annual costs calculated in this manner for many different lengths of season and different manual grade-out percentages form a series of discrete cost points from which a planning equation can be derived as follows:[2/]

$$TSC = \$3{,}036 + \$522R + \$17.334H + \$3.175RH + \$0.116RH\bar{p}. \qquad (22)$$

The above equation can be used to estimate total annual costs of preparing lima beans for freezing for any given size of plant (capacity rate of output), length of operating season, and manual grade-out percentage.

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1/ Estimation of sorting labor cost is simplified by applying the hourly wage of sorters directly to equation (21) and making no attempt to round fractional inputs to the next higher whole number. This procedure underestimates sorting costs slightly but greatly reduces the number of calculations otherwise required.

2/ Where TSC is total season costs, in dollars, of lima bean preparation, R is plant capacity in 1,000 pounds per hour, H is number of hours operated per season, and $\bar{p}$ is manual grade-out percentage.

TABLE 10

Frozen Lima Bean Plants--Preparation Stages:[a/] Variable Costs, Replacement Costs, and Annual Fixed Charges in Relation to Selected Rates of Output California, 1960

Rates of output[b/]	Variable costs					Replacement costs			Annual fixed charges		
	Labor costs			Power, fuel, and repairs[e/]	Total						
	Manual quality grade[c/]	Other labor[d/]	Total labor			Equipment[f/]	Belting[g/]	Total	Equipment[h/]	Belting[i/]	Total
pounds per hour	dollars										
5,000	16.92 + 0.58$\bar{p}$	15.52	32.44 + 0.58$\bar{p}$	2.85	35.29 + 0.58$\bar{p}$	31,169	727	31,896	5,143	182	5,325
10,000	24.82 + 1.16$\bar{p}$	17.46	42.28 + 1.16$\bar{p}$	4.59	46.87 + 1.16$\bar{p}$	49,525	1,127	50,652	8,172	282	8,454
15,000	32.71 + 1.74$\bar{p}$	26.82	59.53 + 1.74$\bar{p}$	5.74	65.27 + 1.74$\bar{p}$	64,741	1,633	66,374	10,682	408	11,090
20,000	40.61 + 2.32$\bar{p}$	31.04	71.65 + 2.32$\bar{p}$	6.53	78.18 + 2.32$\bar{p}$	77,490	1,683	79,173	12,786	421	13,207
25,000	48.50 + 2.90$\bar{p}$	42.34	90.84 + 2.90$\bar{p}$	8.66	99.50 + 2.90$\bar{p}$	98,517	2,182	100,699	16,255	546	16,801
30,000	56.39 + 3.48$\bar{p}$	46.56	102.95 + 3.48$\bar{p}$	9.30	112.25 + 3.48$\bar{p}$	106,122	2,551	108,673	17,510	638	18,148

a/ Preparation operations include receiving, initial cleaning and grading, blanching and second quality grading, and manual quality grading. Calculated from crew and equipment requirements and wage rates given in Tables S-4 and S-5 of the supplement.

b/ Pack-out basis.

c/ Calculated by multiplying the equation for the number of manual quality graders required, $N = 5.101 + 0.892R + 0.0656R\bar{p}$, by the corresponding hourly rate of output and wage rate, where N is the number of sorters, stated in whole numbers, R is plant capacity in 1,000 pounds per hour, pack-out basis, and $\bar{p}$ is manual grade-out percentage.

d/ Includes combined labor costs of the receiving and initial cleaning and grading stages and the blanching and second quality grading stage. For crew requirements and wage rates, see Table S-4 of the supplement.

e/ Electric power estimated at 2.5 cents per horsepower hour. Natural gas fuel estimated at 58.2 cents per 1,000 cubic feet at 1,100 Btu. per hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

f/ Costs of replacing all equipment. For equipment requirements, specifications, and unit prices, see Table S-5 of the supplement.

g/ Calculated by the following equation: $C_b = \$0.41WL + \$0.28NW$, where W is the width of belt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights. Galvanized woven wire or mesh belting estimated by the expression $0.43WL.

h/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

i/ Calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on investment, 3 percent.

Green Pea Preparation and Total Annual Costs

The preparation of green peas and lima beans is identical except in the initial mechanical grading and manual sorting operations. In frozen pea processing, the equipment units for initial grading and temporary storage of lima beans are replaced by a froth-flotation cleaning assembly. The flotation principle depends on the differences in wetability of the peas and the foreign material to be removed rather than on differences in density.1/ Substitution of flotation cleaners for the brining and temporary storage equipment used with lima beans adds an average of approximately $2,700 to equipment investment cost over the output ranges considered and about $450 to the corresponding annual fixed charges. Comparison of the increased costs may be made by comparing Tables 10 and 11.

The sorting standards for lima beans and green peas are equivalent, provided the manual grade-out percentage is defined in relation to the percentage of defects on a count basis as distinguished from weight. When the sorting labor standards are converted to a weight basis, the conversion ratio, count to weight, is different for peas than for beans. On an equal weight basis, 100 baby lima beans are, on the average, roughly equivalent to 190 peas.2/ When the equation for the number of sorters required in relation to volume of plant output per hour and manual grade-out percentage--equation (21)--is adjusted in proportion to count per unit weight, the result for green pea sorting operations becomes:3/

$$N = 5.101 + 1.677R + 0.123R\bar{p} \,. \qquad (23)$$

The costs of variable inputs, equipment replacement costs, and annual fixed charges for the preparation stages of frozen pea plants are summarized

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1/ Variation in wetability allows the process to selectively attach air bubbles to nightshade berries, thistles, weeds, dirt, etc. The process uses an oil-in-water emulsion into which air is incorporated. A foaming agent is added to maintain the stability of the solution and to emulsify the oil and water.

2/ Based on a comparison of a large number of samples obtained from U. S. Department of Agriculture grade inspectors and on samples taken during the study of green pea and lima bean operations. See earlier discussion (page 55) for more details.

3/ Where N is number of sorters required in green pea processing, R is plant capacity in 1,000 pounds per hour, and $\bar{p}$ is manual grade-out percentage.

TABLE 11

Frozen Green Pea Plants--Preparation Stages:[a] Variable Costs, Replacement Costs, and Annual Fixed Charges in Relation to Selected Rates of Output California, 1960

Rates of output[b]	Variable costs					Replacement costs			Annual fixed charges		
	Labor costs			Power, fuel, and repairs[e]	Total						
	Manual quality grade[c]	Other labor[d]	Total labor			Equipment[f]	Belting[g]	Total	Equipment[h]	Belting[i]	Total
pounds per hour	dollars										
5,000	$23.85 + 1.09\bar{p}$	15.52	$39.37 + 1.09\bar{p}$	3.40	$42.77 + 1.09\bar{p}$	31,789	727	32,516	5,245	182	5,427
10,000	$38.68 + 2.18\bar{p}$	17.46	$56.14 + 2.18\bar{p}$	5.33	$61.47 + 2.18\bar{p}$	48,389	1,127	49,516	7,984	282	8,266
15,000	$53.51 + 3.27\bar{p}$	26.82	$80.33 + 3.27\bar{p}$	7.24	$87.57 + 3.27\bar{p}$	68,203	1,633	69,836	11,253	408	11,661
20,000	$68.34 + 4.36\bar{p}$	31.04	$99.38 + 4.36\bar{p}$	8.65	$108.03 + 4.36\bar{p}$	83,227	1,683	84,910	13,732	421	14,153
25,000	$83.17 + 5.45\bar{p}$	42.34	$125.51 + 5.45\bar{p}$	10.49	$136.00 + 5.45\bar{p}$	98,437	2,182	100,619	16,242	546	16,788
30,000	$98.00 + 6.54\bar{p}$	46.56	$144.56 + 6.54\bar{p}$	12.12	$156.68 + 6.54\bar{p}$	113,663	2,551	116,214	18,754	638	19,392

a/ Preparation operations include receiving, initial cleaning and grading, and blanching and second quality grading. Calculated from crew and equipment requirements and wage rates given in Tables S-4 and S-5 of the supplement.

b/ Pack-out basis.

c/ Calculated by multiplying the equation for the number of manual quality graders required, $N = 5.101 + 1.677R + 0.123R\bar{p}$, by the corresponding hourly rate of output and wage rate, where N is the number of sorters, R is plant capacity in 1,000 pounds per hour, pack-out basis, and $\bar{p}$ is manual grade-out percentage.

d/ Includes combined labor costs of the receiving and initial cleaning and grading stages and the blanching and quality grading stage. For crew requirements and wage rates, see Table S-4 of the supplement.

e/ Electric power estimated at 2.5 cents per horsepower hour. Natural gas fuel estimated at 58.2 cents per 1,000 cubic feet at 1,100 Btu. per hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

f/ Costs of replacing all equipment, installed basis. For equipment requirements, specifications, and unit prices, see Table S-5 of the supplement.

g/ Calculated by the following equation: $C_b = \$0.41WL + \$0.28NW$, where W is the width of belt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights. Galvanized woven wire or mesh belting estimated by the expression $0.43WL.

h/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

i/ Calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on investment, 3 percent.

in Table 11. The planning equation relating total annual costs of frozen pea preparation to plant size, length of season, and manual grade-out percentage is:

$$TSC = \$2,765 + \$519R + \$17.478H + \$4.497RH + \$0.218RH\bar{p} . \qquad (24)$$

Lima Bean and Green Pea Packaging

The size of containers considered in this analysis are the common 10-ounce retail cartons, $2\frac{1}{2}$-pound institutional cartons, and 50- or 60-pound bulk bags or cases.1/ The retail style is normally packed to higher grade specifications than are the institutional and bulk styles. The plants synthesized in this section are provided with 100-percent flexibility with respect to container type; that is, packaging facilities are adequate for handling full plant capacity in any of the container sizes specified.

Variations among filling and packaging operations are primarily related to the type of freezing methods used. In California, all observed plants used either tray-tunnel or plate-freeze methods that require packaging retail and institutional cartons before freezing.2/ Prepackaging of the product before freezing--commonly called the "wet pack" method--involves a series of continuous operations. The beans or peas are delivered to the fill stations by a flume system serviced by product pumps. The product passes through a dewater shaker to a pneumatic separator and into an accumulating hopper at each fill station. From the accumulating hopper, it is fed to a mechanical filler for transfer to a retail, institutional, or bulk container (Figure 5).

In the carton-fill operation, bundles of flat cartons are placed in the magazine feed attachment that supplies the mechanical carton former. The cartons are filled as they move beneath cups mounted in a revolving filling cylinder. The filled cartons are segregated onto two conveyors by an interchanger. Workers stationed on each side of the conveyors inspect the filled cartons and remove those improperly formed or filled.

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1/ Recently, a portion of the institutional style has been packed in polyethylene bags.

2/ For a more detailed study of frozen green pea packaging, see G. B. Davis and H. M. Hutchings, Costs and Efficiencies in Pea Freezing Operations: Part 2.--Packaging and Freezing, Oregon Agricultural Experiment Station Miscellaneous Paper 87 (Corvallis, 1960), 27p.

After emerging from automatic closing machines, the cartons are check-weighed and inspected for proper closure. The cartons continue through high-speed wrapping machines and are set off manually in trays and placed in skids or carts for transfer to the freezing tunnel or cabinet.

In the bulk-fill operation, the product feeds from an accumulating hopper to trays passing beneath the filler on a powered roller conveyor. As the trays are filled, they move to a skate-wheel take-off conveyor where they are loaded into skids or carts for transfer to the freezing tunnel. Workers are required for supplying empty trays, attending the fill, setting off filled trays, and transferring the filled skids to the freezing stage. The trays are removed from the freezing tunnel, and the peas or beans are manually dumped into cluster-breaking equipment to transform them into individually quick-frozen (IQF) form and are moved by a spiral conveyor to a bulk-fill station for packaging in 50- or 60-pound bags or cases. The bulk containers are filled, manually weighed, closed, stenciled, and set off to pallets for removal to cold storage.

Equipment arrangement, layout, and organization of the packaging stage will vary among plants according to local conditions and preferences of processors. The design reflected in the above description is a synthesis based on studies of actual plant layouts and on recommendations of processors and equipment manufacturers.

Labor performance standards for the machine-paced jobs described above were calculated from studies of plant data and observation of operations in plants of different capacities. Standards for hand-paced jobs were developed from work sampling studies. Crew requirements in relation to capacity output rates, along with the labor performance standards on which they are based, are given in Table S-6 of the supplement.

Equipment standards for the packaging stages were developed from studies of plant production logs, production studies of packaging operations, and specifications of equipment manufacturers. These standards, given in supplement Table S-7, are used in estimating the separate equipment requirements for each of the container styles. Table S-7 also specifies the requirements for in-stage transportation equipment such as pumps, tubing, and flumes used in distributing the product among the various fill stations.

Variable costs, equipment investment costs, and annual fixed charges, in relation to selected rates of output and styles of container, corresponding

to the crew and equipment requirements given in the supplement tables, are summarized in Table 12. Container and overwrap materials costs were calculated by applying materials prices obtained from manufacturers to container requirements in relation to hourly capacity rates, with indicated allowances for waste.

Estimated Variable Packaging Costs.--Annual variable costs for this stage vary not only with hours operated per season and hourly capacity rates of plant output but also with the proportions packed in the various container sizes. The relationship between hourly variable costs of packaging each of the three styles and hourly volumes of output is shown in Figure 7. As hourly rate of output increases, increasing hourly variable costs with a given style of pack may be represented by a straight line passing through the origin. In this case, hourly variable cost per pound for packaging each container size is constant through the range of capacity rates of packaging considered. Average unit costs per hour based on Figure 7 are \$24.747 per 1,000 pounds packed in retail cartons, \$14.492 per 1,000 pounds packed in institutional cartons, and \$4.582 per 1,000 pounds packed in bulk bags or cases. Hourly variable costs of in-stage distribution vary only to a minor degree with plant capacity and are estimated as \$2.188 per hour of operation.

Total variable packaging costs per season are estimated by applying the unit costs given above to the total season volume packed in each container style. Annual variable costs, including variable costs of in-stage distribution, are:

$$TVC = \$2.188H + \$24.747H_rR + \$14.492H_iR + \$4.582H_bR, \qquad (25)$$

where

TVC = total annual variable costs, in dollars, of packaging lima beans or green peas.

R = plant capacity in 1,000 pounds per hour.

H_r = number of hours operated, retail cartons.

H_i = number of hours operated, institutional cartons.

H_b = number of hours operated, bulk containers.

H = total number of hours operated, all styles of containers.

TABLE 12

Frozen Lima Bean and Green Pea Plants--Packaging Stages: Variable Costs, Replacement Costs, and Annual Fixed Charges
in Relation to Selected Rates of Output and Styles of Pack
California, 1960

Rates of output a/	Retail style										Bulk style					
	Variable costs				Equipment replacement costs			Equipment annual fixed charges			Variable costs				Equipment replacement costs d/	Equipment annual fixed charges f/
	Labor b/	Power and repairs c/	Cartons and wraps	Total	Purchase d/	Lease e/	Total	Purchase f/	Lease g/	Total	Labor b/	Power and repairs c/	Containers h/	Total		
pounds per hour	dollars															
5,000	11.13	1.83	113 i/	125.96	18,653	13,277	31,930	3,078	1,328	4,406	15.52	0.60	13	29.12	5,031	830
10,000	22.26	2.59	225 i/	249.85	28,248	21,150	49,398	4,661	2,115	6,776	25.22	0.66	26	51.88	5,061	835
15,000	31.45	3.68	337 i/	372.13	37,388	26,554	63,942	6,169	2,655	8,824	29.10	1.19	39	69.29	5,931	979
20,000	42.58	4.58	450 i/	497.16	46,326	34,427	80,753	7,644	3,443	11,087	36.86	1.26	52	90.12	6,891	1,137
25,000	50.00	6.17	563 i/	619.17	69,346	39,831	109,177	11,442	3,983	15,425	46.56	1.73	64	112.29	11,680	1,927
30,000	57.59	6.31	675 i/	738.90	66,201	47,704	113,905	10,923	4,770	15,693	58.20	1.80	77	137.00	12,904	2,129
	Institutional style										In-stage distribution costs					
5,000	9.19	1.73	63 j/	73.92	16,728	13,279	30,007	2,760	1,328	4,088	1.94	0.29	k/	2.23	2,997	495
10,000	18.38	1.75	126 j/	146.13	17,938	13,279	31,217	2,960	1,328	4,288	1.94	0.35		2.29	3,800	627
15,000	27.57	3.50	190 j/	221.07	33,456	26,558	60,014	5,520	2,656	8,176	1.94	0.50		2.44	5,310	876
20,000	36.76	3.50	253 j/	293.26	33,616	26,558	60,174	5,547	2,656	8,203	1.94	0.50		2.44	5,310	876
25,000	42.24	3.68	315 j/	360.92	36,056	26,558	62,614	5,949	2,656	8,605	1.94	0.54		2.48	5,782	954
30,000	47.89	5.25	378 j/	431.14	51,820	39,837	91,657	8,550	3,984	12,534	1.94	0.61		2.55	6,826	1,126

a/ Pack-out basis.

b/ Calculated from crew requirements and wage rates given in Table S-6 of the supplement.

c/ Electric power estimated at 2.5 cents per horsepower hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

d/ Costs of replacing all equipment, excluding lease items. For equipment requirements, specifications, and unit prices, see Table S-7 of the supplement.

e/ Annual rental price aggregated for a 10-year period.

f/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

g/ Annual rental charge--rental cost per year calculated on a 10-year basis.

h/ 50-pound bags: plain, multiwall, 1/40 wax, 6-inch tuck-in sleeve, 2/60 wet strength. Price estimated at $128.80 per 1,000 bags. 50-pound cases: price estimated at $128.80 per 1,000 cases.

i/ 10-ounce retail cartons: 5-1/4" x 1-3/8" x 4", 0.015 solid bleach sulphate. Requirements calculated at capacities indicated plus 2 percent waste allowance. Price estimated at $9.77 per 1,000 cartons. 10-ounce overwraps: five-color print. Price estimated at $4.02 per 1,000 wraps.

j/ 2½-pound institutional cartons: 9½" x 5¼" x 2½", 0.020 solid manila for use with mechanical carton-forming and closing equipment. Requirements calculated at capacities indicated plus 0.5 percent waste allowance. Price estimated at $23.71 per 1,000 cartons. 2½-pound overwraps: two-color print. Price estimated at $7.54 per 1,000 wraps.

k/ Blanks indicate does not apply.

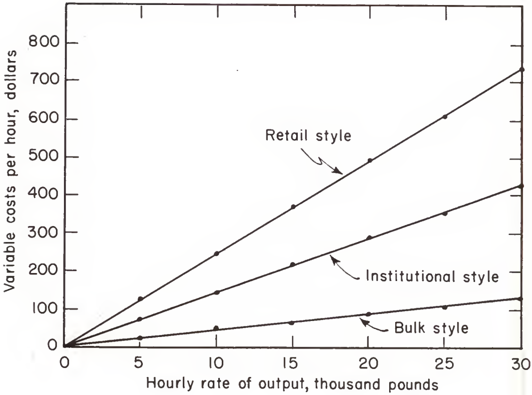

Figure 7. Relation of Hourly Variable Packaging Costs to Hourly Rates of Output in Lima Bean and Green Pea Freezing Plants Equipped to Package Retail, Institutional, and Bulk Containers, California, 1960.

This equation can be used to estimate annual variable packaging costs for any proportion of total season volume that is packed in retail, institutional, or bulk styles.[1/]

Annual Fixed Charges.--The annual fixed charges of packaging equipment for the capacity output rates indicated are given separately for each style of pack in Table 12. The total annual fixed charge of packaging equipment required for handling a given plant capacity is the sum of the annual fixed charges necessary to achieve that rate of output in each of the three container styles. A generalized expression that relates total annual fixed charge given in Table 12 to size of plant is:

$$TFC = \$4,756 + \$880R \;. \qquad (26)$$

Total Annual Packaging Costs.--The generalized total season or planning cost equation for plants packaging any combination of retail, institutional, or bulk container styles is obtained by combining equations (25) and (26) to obtain:

$$TSC = \$4,756 + \$880R + \$2.188H + \$24.747H_rR + \$14.492H_iR + + \$4.582H_bR \;. \qquad (27)$$

Total season costs vary substantially with variations in the proportions packed in each of the three container styles. Table 12 shows that differences in costs of packaging the various containers are primarily attributable to higher costs of the smaller containers.

Total Lima Bean and Green Pea Plant Costs

Planning cost equations representing total annual costs of lima bean and green pea freezing plants are obtained by combining the planning cost equations of Section 1 with those developed in this section. Total annual costs of the general stages and cost components of lima bean and green pea processing given in Table 9 are:[2/]

$$TSC = \$12,554 + \$3,575R + \$6.886H + \$12.414RH + + \$7.817R_rH_r + \$4.655R_rH_r \;. \qquad (28)$$

1/ For any given rate of plant output, H_r/H, H_i/H, and H_b/H are the proportions of total season volume packed in retail, institutional, and bulk styles, respectively.

2/ The variables in equation (28) are defined in Table 9.

The planning cost equation for preparation and packaging operations for lima beans is the sum of equations (24) and (27), giving:

$$TSC_{Lb} = \$7,792 + \$1,402R + \$19.522H + \$3.175RH + \$0.116RH\bar{p} + + \$24.747R_rH_r + \$14.492R_iH_i + \$4.580R_bH_b \quad (29)$$

and for green peas:

$$TSC_{Gp} = \$7,521 + \$1,399R + \$19.666H + \$4.497RH + \$0.218RH\bar{p} + + \$24.747R_rH_r + \$14.492R_iH_i + \$4.58R_bH_b \ . \quad (30)$$

Total plant costs are obtained by combining planning cost equations (28) and (29) for lima beans and equations (28) and (30) for green peas. This gives:

Lima bean plants:

$$TSC_{Lb} = \$20,346 + \$4,977R + \$26.408H + \$15.589RH + + \$0.116RH\bar{p} + \$32.564R_rH_r + \$19.147R_iH_i + \$4.582R_bH_b \quad (31)$$

Green pea plants:

$$TSC_{Gp} = \$20,075 + \$4,974R + \$26.552H + \$16.911RH + \$0.218RH\bar{p} + + \$32.564R_rH_r + \$19.147R_iH_i + \$4.582R_bH_b \quad (32)$$

Equations (31) and (32) can be used to estimate total plant costs of lima bean and green pea processing for any given rate of plant output, number of hours of plant operation per season, manual grade-out percentage, and hours spent in packaging each style of pack. To illustrate the procedure, consider a lima bean plant with a capacity output of 10,000 pounds per hour operating 250 hours packaging retail style cartons and 250 hours packaging institutional style cartons for a total of 500 hours and with a brine concentration in mechanical quality graders such that manual grade-out percentage averages 5 percent. The variables appearing in equation (31) have the following values:

R, R_r, and $R_i = 10$	$H_r = 250$
$H = 500$	$H_i = 250$
$\bar{p} = 5$	$H_b = 0$

Substituting these values in the total cost equation (31) gives a total annual cost of $422,720. The total number of pounds packed during the season is the product of the rate of hourly output and the number of hours operated,

or 5 million pounds. Dividing this amount into estimated total costs gives a unit cost of plant operations of about $8\frac{1}{2}$ cents per pound.[1/]

Frozen Brussels Sprouts Plants

Major steps in the preparation and packaging of Brussels sprouts for freezing are indicated by the equipment layout (Figure 8). Preparation includes size grading, trimming, cleaning, blanching, and quality grading, while packaging involves carton-filling, manual check-weighing, wrapping, and tray-off operations.

Brussels sprouts are delivered to the plant by flatbed trucks or semi-trailers in wooden bins that are approximately 47" x 47" x 48".[2/] At the plant receiving yard, the loaded bins are set off by fork truck and transferred to a temporary storage location adjacent to the size-grading station.

Brussels Sprouts Preparation

Size Grading and Trimming.--The bins are picked up and removed from temporary storage by fork truck and placed on a cradle-type mechanical bin dumper. The sprouts are dumped into a large receiving hopper from which they are belt elevated about 10 feet to a size-grading assembly where they are mechanically separated into five size categories. Grades are classified according to base diameter of the individual sprouts. No. 1's are less than 3/4 inch in base diameter; No. 2's range from 3/4 to 1-1/8 inches; No. 3's, from 1-1/8 to 1-1/4 inches; No. 4's, from 1-1/4 to 1-3/8 inches; and No. 5's (jumbos) are those over 1-3/8 inches. In general, only sizes 2, 3, and 4 are considered commercially significant.

The mechanical size grader contains a series of diverging steel rods that form channels on which the sprouts travel. The channels gradually diverge in width so that small sprouts drop first and the large sprouts last. Nibble rods are installed between the sizing channels to position

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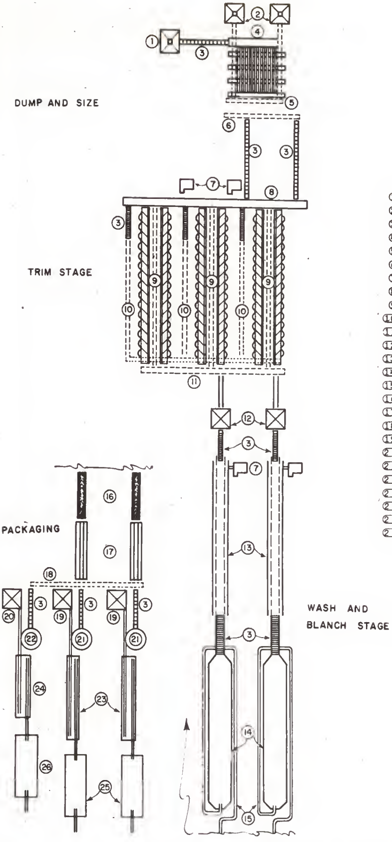
1/ Recall that this estimate does not include raw product and selling cost (see page 30).

2/ Dimensions of the bins used vary slightly among plants. Another common size is 48" x 48" x 41".



LEGEND

1. Mechanical Dump Assembly – Ungroded Sprouts
2. Mechanical Dump Assembly – Groded Sprouts
3. Flight Conveyor
4. Size Grading Assembly – 10' elevotion
5. Cross Conveyor
6. Cross Conveyor
7. Woter Pressure Boost Pumps
8. Cross Conveyor to Trim Lines – 15' elevation
9. Trim Toble Assembly (3)
10. Constant Supply Conveyors
11. Cross Collection Conveyor
12. Pneumotic Seporotors (de-leafers) (2)
13. Flood-type Wash Assembly (2)
14. Steam Blanch Assembly (2)
15. Cooling Flumes
16. Mesh Drain Conveyors (2)
17. Inspection and Manual Grade Lines
18. Cross Conveyor to Institutionol Fill Line
19. Retail Corton Forming Assembly (2)
20. Institutionol Carton Forming Assembly (1)
21. Retail Mechanicol Fillers (2)
22. Institutionol Mechanical Fillers (1)
23. Retail Weigh Lines (2)
24. Institutionol Weigh Lines (1)
25. Retoil Corton Wroppers (2)
26. Institutionol Corton Wrappers (1)

Capacity: 5 to 6 tons per hour; approximate scale: .042" = 1'

Figure 8. Layout of a Specialized Frozen Brussels Sprouts Line, California, 1960.

the sprouts for proper grading. The different sizes drop through the shaker-screen onto several reversible cross conveyors which permit the operator-attendant to return one or more sizes to bins for temporary holding. The remaining output is deposited on side collection belts and is elevated to the trimming stage. The sizes transferred to temporary storage are later redumped (equipment item 2 in Figure 8) and conveyed directly to the trimming section.

In the trimming stage, the stem end of each sprout is removed by a water-powered trimming machine, or Hydrout.1/ These machines usually are installed in a series of back-to-back pairs with a supply belt running between the pairs (equipment item 9, Figure 8). Hydropumps and associated connecting pipes are required to boost water pressure at the Hydrouts to about 200 pounds per square inch. Additional equipment of the trim line assembly includes an inclined product supply bin and disposal chute for each operator, a collection conveyor for the trimmed product, and a constant-supply conveyor or "merry-go-round" to return overflow of untrimmed sprouts to trimmers.

The labor performance standard for trimming Brussels sprouts by Hydrout operation, developed by work sampling studies in cooperating plants, is 85 sprouts per minute per trimmer, irrespective of size. When converting the standards to a pounds-per-hour basis, however, the size distribution of the sprouts must be considered. There are an average of 39 trimmed sprouts of size No. 2 per pound, 24 of size No. 3, and 17 of the No. 4 size category.2/ With a labor performance standard of 85 sprouts per minute, the pound equivalent of this standard becomes 131 pounds per hour of size No. 2 sprouts and 213 and 300 pounds per hour of sizes No. 3 and No. 4, respectively.

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1/ "Hydrout" is the trademark of a trimming and coring machine manufactured by Magnuson Engineers, Inc. It is powered by a water pressure jet that turns a turbine wheel on which a cutting knife is mounted. The depth of cut is controlled by a rubber diaphragm cover.

2/ These data were developed from count-weight relationships observed through samples taken in the plants studied and data obtained from numerous additional samples made available by U. S. Department of Agriculture grade inspectors.

Allowing a 20-percent weight loss in trimming, the standards, based on the output of trimmed sprouts, are 105 pounds per trimmer-hour of size No. 2 sprouts, 170 pounds of size No. 3, and 240 pounds of size No. 4.[1/] These are the "effective" labor performance standards for trimming expressed on a trimmed weight basis.

A generalized expression of the number of Hydrout operators (trimmers) as related to the percentage of sprouts run by size classification is:

$$T = 0.0952P_1R + 0.0588P_2R + 0.0417P_3R, \qquad (33)$$

where

T = number of Hydrout operators (trimmers) required.

P_1 = percentage of total plant capacity comprising No. 2 sprouts.

P_2 = percentage of total plant capacity comprising No. 3 sprouts.

P_3 = percentage of total plant capacity comprising No. 4 sprouts.

R = total plant capacity, in 1,000 pounds per hour, with 20 percent of the raw product trimmed out.

Equation (33) can be used to estimate the number of Hydrout operators required for any given rate of output and specified size distribution. To illustrate, consider a plant that is processing 5,000 pounds of Brussels sprouts per hour with a size distribution comprised of 80 percent size No. 2 and 10 percent each of sizes No. 3 and No. 4. Substituting these values in equation (33) gives: $T = 0.0952(80)(5) + 0.0588(10)(5) + 0.0417(10)(5) = 43.1$. Forty-four trimmers are required for a plant operating under these conditions when fractional trimmer requirements are adjusted to the next whole number.[2/] Additional labor includes attendants for operating equipment and regulating product flow. Production standards and crew requirements for the size-grading and trimming stages are given in Table S-8 of the supplement.

The number of Hydrout machines required is, of course, directly related to the labor performance standards for trimmers. Consequently, Hydrout

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1/ Weight loss in trimming will also vary according to the size distribution of the sprouts handled. Twenty percent represents an average of such losses in the plants studied.

2/ In estimating trimmer costs, wage rates of the trimmers are applied directly to equation (33), and fractional labor requirements are not rounded to the next higher whole number. This simplifies the computations without significantly affecting the results.

requirements, like labor inputs, depend on the size distribution of Brussels sprouts for any given output rate measured in pounds per hour. As the size distribution of sprouts processed may vary considerably, the installation should provide adequate trimming facilities for handling substantial variations in sizes. This implies that enough machines must be available to handle a large percentage of the specified volume in the smallest size category processed--size No. 2. As the proportions handled of sizes 3 and 4 increase, the number of pounds trimmed per hour increases, and the stages preceding and following the trimming operation must have sufficient capacity to handle the added volume.

The ideal solution to this problem would involve analysis of requirements and costs for the various stages over the range of likely size variation and the selection of a cost-minimizing "balance" of stage capacities. Data on size variation are not available in the amount and detail required, so plant design is patterned after the practical solution observed in cooperating plants. Accordingly, the Brussels sprouts plants synthesized in this study are designed with flexible trimming facilities adequate to handle a size distribution of 80 percent size No. 2 sprouts, and the other operating stages are designed to handle outputs related to sprouts of a large size--here taken as size No. 4. Equipment requirements for the size grading and trimming stages, including detailed specifications and unit prices, are given in Table S-9 of the supplement.

Cleaning, Blanching, and Quality Grading.--After trimming, the sprouts continue to a cross collection conveyor and are diverted to pneumatic separators for elimination of any loose outer leaves that remain. The air separator consists of a large galvanized iron air stack with a discharge chute, screen, and blower at the base. The loose leaves are picked up in the air stream of the blower and carried out the stack to waste disposal facilities. The whole sprouts drop gently down the air stack and through the discharge chute.

As the sprouts discharge from the pneumatic separator, they are collected on a flight conveyor and delivered to a flood-type wash assembly. The wash tanks are equipped with overhead pressure sprays supplied by a hydropump and usually are provided with a chemical dispenser for aphis control. At the discharge end of the wash assembly, a wire-mesh draper transfers the sprouts to a flight conveyor leading to the blancher.

Blanching time for Brussels sprouts varies from $3\frac{1}{2}$ to $4\frac{1}{2}$ minutes, depending on the size of the sprouts, their temperature, and the temperature in the processing plant. In this study, blanching equipment and service inputs (steam and water) requirements are based on a 4-minute exposure time. The blanching unit is of conventional type consisting of an enclosed welded steel tank with appropriate water and steam inlets, steam banks and manifolds, exhaust stacks, and a waste water drain. The sprouts are conveyed through the blanching unit on a galvanized woven wire conveyor driven by a variable-speed motor. Additional equipment includes an automatic temperature control unit and instrumentation to assist the operator in maintaining proper blanch temperatures and exposure times.

The sprouts are discharged from the blancher into cooling flumes from which they move over a wire-mesh dewatering belt to the inspection and quality grading stage. Sorting belts are usually from 24 to 30 inches in width with 6-inch side tracks on which the lower grades are placed and with chutes to a floor trench for disposal of defective sprouts. Improperly trimmed sprouts are placed in buckets or pans and returned for manual trimming to workers stationed at either end of the sorting line. A procedure similar to that described for lima beans was used for the development of sorting standards.

Total Annual Preparation Costs.--The detailed equipment and variable input requirements given in Tables S-8 and S-9 of the supplement are used to calculate variable costs, equipment replacement costs, and annual fixed charges for the preparation stages of Brussels sprouts processing. The results, given in Table 13, are used to compute total season cost points for selected output rates, size distribution, and length of operating season.

The total cost points so derived provide the basis for the planning cost equation:

$$TSC = \$5{,}093 + \$712R + \$14.050H + (\$2.760 + \$0.1685P_1 + \\ + \$0.1041P_2 + \$0.0738P_3 + \$0.1161\bar{p})RH \, . \qquad (34)$$

With any specified plant capacity output rate, length of operating season, size distribution of the sprouts processed, and percentage of manual grade-out, equation (34) can be used to estimate total annual costs of the equipment and variable inputs for the Brussels sprouts preparation stages.

TABLE 13

Frozen Brussels Sprouts Plants--Preparation Stages: Variable Costs, Replacement Costs, and Annual Fixed Charges in Relation to Selected Rates of Output
California, 1960

Rates of output[a/]	Variable costs: Labor costs: Trim[b/]	Variable costs: Labor costs: Manual quality grade[c/]	Variable costs: Labor costs: Other labor[d/]	Variable costs: Power, fuel, and repairs[e/]	Variable costs: Total	Replacement costs: Equipment[f/]	Replacement costs: Belting[g/]	Replacement costs: Total	Annual fixed charges: Equipment[h/]	Annual fixed charges: Belting[i/]	Annual fixed charges: Total
pounds per hour	dollars										
2,000	$0.337P_1 + 0.208P_2 + 0.148P_3$	$6.875 + 0.2322\bar{p}$	9.52	4.37	$20.765 + 0.337P_1 + 0.208P_2 + 0.148P_3 + 0.2322\bar{p}$	32,986	2,380	35,366	5,443	595	6,038
4,000	$0.674P_1 + 0.416P_2 + 0.295P_3$	$10.032 + 0.4644\bar{p}$	9.52	4.72	$24.272 + 0.674P_1 + 0.416P_2 + 0.295P_3 + 0.4644\bar{p}$	35,672	2,637	38,309	5,886	659	6,545
6,000	$1.011P_1 + 0.625P_2 + 0.443P_3$	$13.225 + 0.6966\bar{p}$	9.52	7.58	$30.325 + 1.011P_1 + 0.625P_2 + 0.443P_3 + 0.6966\bar{p}$	58,588	3,799	62,387	9,667	950	10,617
8,000	$1.348P_1 + 0.833P_2 + 0.590P_3$	$16.348 + 0.9288\bar{p}$	9.52	8.17	$34.038 + 1.348P_1 + 0.833P_2 + 0.590P_3 + 0.9288\bar{p}$	64,825	3,946	68,771	10,696	987	11,683
10,000	$1.685P_1 + 1.041P_2 + 0.738P_3$	$19.505 + 1.1610\bar{p}$	9.52	9.06	$38.085 + 1.685P_1 + 1.041P_2 + 0.738P_3 + 1.1610\bar{p}$	67,696	4,065	71,761	11,170	1,016	12,186
12,000	$2.022P_1 + 1.249P_2 + 0.886P_3$	$22.663 + 1.3932\bar{p}$	19.04	9.90	$51.603 + 2.022P_1 + 1.249P_2 + 0.886P_3 + 1.3932\bar{p}$	78,347	4,538	82,885	12,927	1,135	14,062
14,000	$2.359P_1 + 1.457P_2 + 1.033P_3$	$25.821 + 1.6254\bar{p}$	19.04	10.62	$55.481 + 2.359P_1 + 1.457P_2 + 1.033P_3 + 1.6254\bar{p}$	84,933	4,715	89,648	14,014	1,179	15,193
16,000	$2.696P_1 + 1.666P_2 + 1.181P_3$	$28.978 + 1.8576\bar{p}$	19.04	11.26	$59.278 + 2.696P_1 + 1.666P_2 + 1.181P_3 + 1.8576\bar{p}$	91,994	4,921	96,915	15,179	1,230	16,409
18,000	$3.033P_1 + 1.874P_2 + 1.328P_3$	$32.136 + 2.0898\bar{p}$	19.04	12.08	$63.256 + 3.033P_1 + 1.874P_2 + 1.328P_3 + 2.0898\bar{p}$	99,592	5,378	104,970	16,433	1,345	17,778
20,000	$3.370P_1 + 2.082P_2 + 1.476P_3$	$35.294 + 2.3220\bar{p}$	19.04	12.57	$66.904 + 3.370P_1 + 2.082P_2 + 1.476P_3 + 2.3220\bar{p}$	105,128	5,525	110,653	17,346	1,381	18,727

a/ Pack-out basis. A natural recovery rate of 80 percent is assumed. For labor performance standards, wage rates, and crew requirements, refer to Table S-8 of the supplement.

b/ Calculated by multiplying the equation for the number of trimmers required, $T = 0.0952P_1R + .0588P_2R + .0417P_3R$, by the corresponding hourly rate of output and wage rate, where T is the number of trimmers, P_1 is the percentage of total rate of output comprising size No. 2 sprouts, P_2 is the percentage of size No. 3, P_3 is the percentage of size No. 4, and R is the total rate of output per hour in 1,000 pounds.

c/ Calculated by multiplying the equation for the number of manual quality graders required, $N = 2.100 + .0656R\bar{p}$, by the corresponding hourly rate of output and wage rate, where N is the number of graders, R is plant capacity in 1,000 pounds per hour, pack-out basis, and $\bar{p}$ is manual grade-out percentage.

d/ Includes size grader, Hydrout, blanchers, and boiler attendants.

e/ Electric power estimated at 2.5 cents per horsepower hour. Natural gas fuel estimated at 58.2 cents per 1,000 cubic feet at 1,100 Btu. per hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

f/ Costs of replacing all equipment. For equipment requirements, specifications, capacities, and unit prices, see Table S-9 of the supplement.

g/ Calculated by the following equation: $C_b = \$0.41WL + \$0.28NW$, where W is the width of belt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights. Galvanized woven wire or mesh belting estimated by the expression $0.43WL.

h/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

i/ Calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on investment, 3 percent.

Brussels Sprouts Packaging

Packaging of Brussels sprouts involves a series of highly integrated machine- and hand-paced operations in which the cartons are formed, filled, check-weighed, closed, wrapped, and trayed off to freezer skids or carts.

Retail Packaging.1/--In retail packaging, all operations except check-weighing are done mechanically. Bundles of flat cartons are placed in a feed magazine leading to an automatic carton-forming machine where the cartons are opened or set up.2/ The open cartons emerge from the forming machine onto a conveyor and move to a mechanical filler.3/ The filler is a straight-line, volumetric-fill type consisting of a revolving stainless steel disc with closely spaced filling pockets along the outer edge and a slightly depressed area in the center for holding the product to be filled. Workers stationed around the perimeter of the revolving table fill the pockets from which sprouts are transferred to cartons passing beneath.

The filled cartons move directly to the weigh line where each is check-weighed. In this operation, workers grasp two cartons and place or slide them onto separate scales. While on the scales, the weight of each carton is adjusted by adding or removing individual sprouts as necessary. Labor performance standards for any individual check-weigh worker vary according to the continuity of carton flow on the belt and according to the position of the workers in the weighing line. As the first weighers on the line remove some cartons, the flow or spacing of cartons reaching successive workers becomes irregular, which results in momentary delays. Also, some time is lost because space on the set-off conveyor has to be sought occasionally among the cartons weighed by preceding workers. Time and production studies were made of workers in relation to their position in the weigh line. These data were developed into a generalized expression showing the number of pounds of Brussels sprouts check-weighed per worker hour in relation to the line position of the worker. This relationship is given by the equation: $Y = 1{,}042.0 - 70.1X$, where Y is the number of pounds

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1/ Ten-ounce cartons.

2/ The carton-forming, carton-closing, and "Prespak" equipment is manufactured by Kliklok Corporation.

3/ Food Machinery Corporation or custom-built fillers.

check-weighed per worker hour, and X is the line position of each pair of workers.[1] This equation is then used to estimate crew and equipment requirements for the check-weighing stage.

From the check-weighing stage, the filled cartons continue through a Prespak machine where the product in each carton is automatically leveled. They then move through carton-closing machines and high-speed wrappers and are manually set off in trays and placed in freezing carts for removal to the freezing tunnels or cabinets. Detailed crew requirements in relation to selected rates of output for the retail--and institutional--packaging operations are given in Table S-10, while equipment requirements, specifications, and unit prices are given in Table S-11 of the supplement.

Institutional Carton Packaging.--Two methods--machine and manual--are used in packaging institutional cartons. With Method A--machine fill--the procedures are identical to those applicable to the retail packaging operations described above.

In Method B--manual fill--the jobs of forming, filling, weighing, and closing the cartons are performed manually. The filling line is usually 30 inches wide with 6-inch side tracks for carrying away the filled cartons. Workers stationed on each side of the supply belt get and form flat cartons from an adjacent location and place them in position for filling. Sprouts are picked up in both hands and placed in the carton. The filled cartons proceed to the check-weigh workers, who pick up each carton from the line, place it on a scale, and remove or add product to attain the specified weight. The cartons are then set aside to a 6-inch carton run situated 6 or 8 inches above and between the two belts supplying the empty cartons. Variable costs and annual fixed charges given in Table 14 provide the basis for comparing the relative costs of the two methods. Method A is the least-cost method over all ranges of output rates considered.[2]

Variable Packaging Costs.--When the total hourly variable cost points given in Table 14 are related to the corresponding hourly rates of output,

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1/ Because of limitations in data, the equation is not considered valid except for the range $4 \leq X \leq 8$.

2/ Planning cost equations with Method A and Method B are as follows: $TSC_A = \$3,300 + \$350R + \$1.42H + \$15.78RH$ and $TSC_B = \$1,700 + \$230R + \$0.55H + \$25.95RH$. For any specified rate of output and number of hours operated within the range considered, $TSC_A \leq TSC_B$.

TABLE 14

Frozen Brussels Sprouts Plants--Packaging Stages: Variable Costs, Replacement Costs, and Annual Fixed Charges in Relation to Selected Rates of Output, Styles of Pack, and Methods Used
California, 1960

		Retail style											
		Variable costs				Replacement costs				Annual fixed charges			
						Equipment				Equipment			
Rates of output[a]	Common costs[b]	Labor[c]	Power and repairs[d]	Cartons and wraps	Total	Purchase[e]	Lease[f]	Belting[g]	Total	Purchase[h]	Lease[i]	Belting[j]	Total
pounds per hour	dollars												
2,000	1,068	12.90	1.95	45.01[k]	59.86	18,601	18,186	234	37,021	3,069	1,819	59	4,947
4,000	1,780	21.92	1.97	90.02[k]	113.91	18,851	18,186	284	37,321	3,110	1,819	71	5,000
6,000	2,848	32.54	3.91	135.03[k]	171.48	37,402	36,372	505	74,283	6,171	3,637	127	9,935
8,000	3,560	38.02	3.93	180.04[k]	221.99	37,702	36,372	569	74,643	6,221	3,637	142	10,000
10,000	4,272	45.27	3.96	225.05[k]	274.28	38,202	36,372	667	75,241	6,303	3,637	167	10,107
12,000	5,340	54.12	5.90	270.06[k]	330.08	56,553	54,558	852	111,963	9,331	5,456	213	15,000
14,000	6,408	65.25	5.91	315.07[k]	386.23	56,703	54,558	882	112,143	9,356	5,456	221	15,033
16,000	7,120	74.10	7.85	360.08[k]	442.03	75,204	72,744	1,098	149,046	12,409	7,274	275	19,958
18,000	8,188	81.35	7.88	405.10[k]	494.33	75,604	72,744	1,176	149,524	12,475	7,274	294	20,043
20,000	8,900	88.60	7.91	450.11[k]	546.62	76,204	72,744	1,294	150,242	12,574	7,274	324	20,172
		Institutional style--Method A											
2,000	[l]	9.19	1.97	25.13[m]	36.29	17,286	17,426	283	34,995	2,852	1,743	71	4,666
4,000		16.44	1.97	50.25[m]	68.66	17,286	17,426	283	34,995	2,852	1,743	71	4,666
6,000		19.98	2.00	75.38[m]	97.36	17,503	17,426	332	35,261	2,888	1,743	83	4,714
8,000		25.46	2.02	100.50[m]	127.98	17,753	17,426	332	35,511	2,929	1,743	83	4,755
10,000		29.00	2.02	125.63[m]	156.65	17,753	17,426	382	35,561	2,929	1,743	96	4,768
12,000		36.08	3.87	150.75[m]	190.70	34,629	34,852	703	70,184	5,714	3,485	176	9,375
14,000		43.50	3.87	175.88[m]	223.25	34,629	34,852	703	70,184	5,714	3,485	176	9,375
16,000		47.04	5.01	201.00[m]	253.05	34,979	34,852	863	70,694	5,772	3,485	2.6	9,473
18,000		50.58	5.03	226.13[m]	281.74	35,279	34,852	923	71,054	5,821	3,485	231	9,537
20,000		56.06	5.04	251.25[m]	312.35	35,379	34,852	941	71,172	5,838	3,485	325	9,558
		Institutional style--Method B											
2,000		19.98	0.85	35.24[n]	56.07	14,615	--[o]	413	15,028	2,411	--	103	2,514
4,000		36.08	0.89	70.48[n]	107.45	15,215	--	585	15,800	2,510	--	146	2,656
6,000		52.18	1.04	105.72[n]	158.94	16,032	--	805	16,837	2,645	--	201	2,846
8,000		58.28	1.07	140.96[n]	210.31	16,532	--	949	17,481	2,728	--	237	2,965
10,000		82.44	1.11	176.20[n]	259.75	17,132	--	1,119	18,251	2,827	--	280	3,107
12,000		98.54	1.24	211.44[n]	311.22	17,632	--	1,262	18,894	2,865	--	316	3,181
14,000		114.64	1.99	246.68[n]	363.31	32,087	--	1,763	33,850	5,294	--	441	5,735
16,000		130.74	2.03	281.91[n]	414.68	32,737	--	1,907	34,644	5,402	--	477	5,879
18,000		146.84	2.06	317.15[n]	466.05	33,237	--	2,050	35,287	5,484	--	513	5,997
20,000		162.94	2.12	352.39[n]	517.45	34,037	--	2,278	36,315	5,616	--	570	6,186

a/ Pack-out basis.

b/ Replacement costs--scales and pans for weigh lines, all styles and forms.

c/ Calculated from crew requirements and wage rates given in Table S-10 of the supplement.

d/ Electric power estimated at 2.5 cents per horsepower hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

e/ Costs of replacing all equipment, excluding leased items. For equipment requirements, specifications, and unit prices, see Table S-11 of the supplement.

f/ Annual rental price aggregated for a 10-year period.

g/ Calculated by the following equation: $C_b = \$0.41WL + \$0.28NW$, where W is the width of belt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights. Galvanized woven wire or mesh belting estimated by the expression $0.43WL.

h/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

i/ Annual rental charge--rental cost per year calculated on a 10-year basis.

j/ Calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on investment, 3 percent.

k/ 10-ounce retail cartons: 5-1/4" x 1-3/8" x 4", 0.015 solid bleach sulphate. Requirements calculated at capacities indicated plus 2 percent waste allowance. Price estimated at $9.77 per 1,000 cartons. 10-ounce overwraps: five-color print. Price estimated at $4.02 per 1,000 wraps.

l/ Blanks indicate included above.

m/ 2½-pound institutional cartons: 9½" x 5¼" x 2½", 0.020 solid manila for use with mechanical carton-forming and closing equipment. Requirements calculated at capacities indicated plus 0.5 percent waste allowance. Price estimated at $23.71 per 1,000 cartons. 2½-pound overwraps: two-color print. Price estimated at $7.54 per 1,000 wraps.

n/ 2½-pound institutional cartons: 9½" x 5¼" x 2½", 0.017 solid manila, corner gussets, for use with manual carton-forming and closing equipment. Requirements calculated at capacities indicated plus 0.5 percent waste allowance. Price estimated at $36.29 per 1,000 cartons. 2½-pound overwraps: two-color print. Price estimated at $7.54 per 1,000 wraps.

o/ Dashes indicate does not apply.

they may be represented by a linear equation through the origin. This implies that hourly variable costs per unit of product in retail or institutional cartons are independent of the scale of operations.[1] A generalized expression, relating total variable packaging costs to capacity rates of packaging and size of carton, is:

$$TVC = \$27.351R_r + \$15.679R_i, \tag{35}$$

where

R_r = rate of packaging retail cartons, in 1,000 pounds per hour.

R_i = rate of packaging institutional cartons, in 1,000 pounds per hour.

Annual Fixed Charges.--Annual fixed charges for selected capacity rates for each style of container are the sum of the fixed charges necessary to achieve that rate of output in any of the three styles, plus the annual fixed charges common to both (Table 14). A generalized expression showing how the combined annual fixed charges of packaging Brussels sprouts varies with the size of plant, measured in capacity packaging rates, is:

$$TFC = \$5,770 + \$1,755R. \tag{36}$$

Total Annual Packaging Costs.--Total annual packaging costs for any specified length of season are obtained by multiplying equation (35) by the number of hours operated per season and adding to it the annual fixed costs in equation (36). An expression of total season, or planning, costs calculated on this basis is given in equation (37) and may be used to estimate the total annual costs of packaging Brussels sprouts for any given length of season, proportions packed in retail or institutional container styles, and rate of plant output.

$$TSC = \$5,770 + \$1,755R + \$27.351R_rH_r + \$15.679R_iH_i. \tag{37}$$

Total Brussels Sprouts Plant Costs

When the planning cost equations of the preparation and packaging stages are combined with those of the general stages and cost components developed

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[1] See page 65 for greater elaboration of this point.

in Section 1, planning cost equations representing total plant costs of processing Brussels sprouts for freezing are obtained.[1] The result is:[2]

$$
\begin{aligned}
TSC_{BrSp} = {} & \$23{,}137 + \$6{,}159R + \$20.327H + \$15.529RH + \\
& + \$0.116RH\bar{p} + \$35.168R_rH_r + \$20.334R_iH_i + \\
& + \$0.169P_1RH + \$0.104P_2RH + \$0.074P_3RH\,.
\end{aligned} \tag{38}
$$

Frozen Broccoli Plants

The in-plant handling and operating stages in preparing and packaging frozen broccoli are shown in Figure 9. This process layout represents a synthesis based on studies of plant operations and equipment and layouts and on recommendations of processors and equipment manufacturers.

Broccoli Preparation

Dumping and Trimming.--Broccoli usually is received in large wooden bins of a type described earlier.[3] If the length of haul or plant scheduling is such that the broccoli cannot be processed immediately, it must be iced at the field harvesting location and either removed to a cool-storage holding room or perhaps re-iced when it arrives at the plant receiving yard. Otherwise, the heads blossom soon after cutting.

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1/ Planning cost equations for general stages and cost components are given in Table 9.

2/ TSC_{BrSp} = total season costs, in dollars, of processing Brussels sprouts.

R = plant capacity in 1,000 pounds per hour.

H = number of hours operated per season.

R_rH_r = total season volume, retail cartons, in 1,000 pounds per hour.

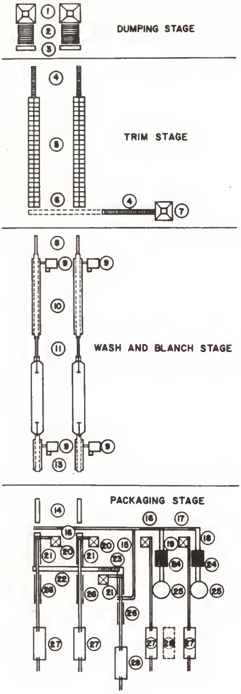
R_iH_i = total season volume, institutional cartons, in 1,000 pounds per hour.

P_1RH = percentage of total plant capacity comprising No. 2 sprouts.

P_2RH = percentage of total plant capacity comprising No. 3 sprouts.

P_3RH = percentage of total plant capacity comprising No. 4 sprouts.

3/ This is the most common method, although several of the plants studied, particularly those situated within specialized production areas, use tractor-drawn field trailers to haul the broccoli from the field to the plant.



LEGEND

1 Mechanical Bin Dump Assembly (2)
2 Slat-type Conveyor (2)
3 Cross Collection Conveyors (2)
4 Flight Conveyors (3)
5 Trim Table Assembly; Bin Type (2)
6 Woste Conveyor; Trim
7 Woste Collection Hopper or Garboge Screen
8 Washer Feed Conveyors (2)
9 Water Pressure Booster Pumps (4)
10 Flood-type Wash Assembly (2)
11 Blanch Feed Conveyors (2)
12 Steam Blanch Assembly (2)
13 Flood-type Cooling Assembly (2)
14 Mesh Conveyors (2)
15 Flume to Chop Lines
16 Flight Conveyor
17 Conveyor to Chop Line No. 2
18 Feed Conveyors to Choppers (2)
19 Retail ond Institutional Carton Forming Assembly – Chop Lines (2)
20 Retail Carton Forming Assembly – Spear Lines (2)
21 Inspection and Packing Lines – Spears (3)
22 Cross Conveyor to Institutional Hand Pack Line
23 Flight Conveyor
24 Choppers (2)
25 Retail and Institutional Corton Filling Assembly – Chop Lines (2)
26 Weight Lines (3)
27 Retail Carton Wrappers (4)
28 Institutional Carton Wrappers (2)

Capacity: 5 to 6 tons per hour; approximate scale: .025" = 1'

Figure 9. Layout of a Specialized Frozen Broccoli Line, California, 1960.

The bins are dumped slowly by an electrically driven bin-dumping machine onto a wide apron-type receiving conveyor, and the product moves to a cross-belt that deposits it on a flight conveyor leading to the trimming stage.

Two methods of trimming were studied that differ primarily in the way incoming broccoli is supplied to the trimmers. In the bin supply method, the trim line is a series of inclined bins or tubs on either side of an overhead supply conveyor (Figure 9). Workers reach up and forward 12 to 18 inches to grasp each head of broccoli and place it on a cutting block attached to the supply bin. The heads are then manually cut to length with a 4- to 6-inch trimming knife, the leaves and spurs are trimmed off, and the head is split into individual spears. The trimmed spears are cast aside to a collection belt that runs below the overhead supply conveyor and between the worker supply bins. The stem ends, leaves, and sort-outs are raked into a waste disposal chute to the bottom portion of the collection conveyor and delivered to a belt or floor trench leading to waste disposal facilities. In addition to trimmers, one or more workers are required to regulate the flow of product.

With the conveyor supply method of trimming, the broccoli is delivered on a 30-inch supply conveyor placed at right angles to the trim conveyors. The broccoli usually is distributed to the trim lines by revolving paddle wheels of different diameters, each equipped with a brush attachment. As the wheels revolve, the broccoli is raked off to each of the trim lines. Workers stationed on both sides of the lines trim the separate heads of broccoli in the same manner as in the bin supply method described above. The broccoli that trimmers are unable to handle because of a line overload passes over the trim belt to a cross return conveyor and is recirculated to the main supply belt and trim lines. One or more workers also are required with this method to regulate the flow of product.

Labor performance standards for the trimming operation vary according to raw product quality as well as the type of trim specified by different buyers. Some buyers require a close trim of the individual heads, including removal of all leaves and spurs, and close conformity in the diameter of spears. In most cases, these trim specifications are above U. S. Department of Agriculture Grade A standards and result in increased labor inputs and higher costs. The results of work-sampling studies indicate that the output per trimmer is approximately 10 pounds per hour less with

the "high" trim than with the "standard," or U. S. Department of Agriculture, trim specifications. The value selected for use in estimating trimming stage labor requirements is 110 pounds per trimmer per hour and is applicable to U. S. Department of Agriculture Grade A specifications.

Comparison of trimming labor standards of the bin and conveyor supply methods indicates no significant differences in the labor performance standards between methods. The conveyor supply method requires slightly more expensive equipment, however, and costs of the specialized broccoli plants synthesized in this section are based on the bin supply method.1/ Equipment requirements and cost comparisons for each method are given in Table S-12 of the supplement.

Cleaning and Blanching.--Trimmed broccoli is delivered directly or by cross distribution conveyors into a flood-type wash assembly through which it is hydro-conveyed to a wire-mesh draper and then elevated into a conventional blanch unit. From blanching, the spears are delivered to cooling tanks where they are cooled by immersion in a water bath and by overhead pressure or fog sprays.

Total Annual Preparation Costs.--Detailed crew requirements and the production standards on which they are based are given in Table S-13 of the supplement, while equipment requirements, specifications, and unit installed prices are given in Table S-14. Variable costs, equipment replacement costs, and annual fixed charges in relation to selected rates of capacity and methods used are given in Table 15.

Following procedures described in the cost synthesis for lima beans and Brussels sprouts processing, total season cost points for any given rate of output and length of operating season are calculated from data in Table 15. From these cost points, a generalized expression of planning costs as related to capacity output rate and length of operating season is given by the planning equation:

$$TSC = \$3,434 + \$804R + \$9.972H + \$17.800RH . \quad (39)$$

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1/ Where multiple products are processed, the basic broccoli line is modified to include the conveyor supply method of trimming. See Part IV of this study.

TABLE 15

Frozen Broccoli Plants--Preparation Stages: Variable Costs, Replacement Costs and Annual Fixed Charges in Relation to Selected Rates of Output
California, 1960

Rates of output a/	Variable costs			Replacement costs			Annual fixed charges		
	Labor b/	Power, fuel, and repairs c/	Total	Equipment d/	Belting e/	Total	Equipment f/	Belting g/	Total
pounds per hour	dollars								
2,000	44.25	3.84	48.09	28,287	2,723	31,010	4,667	681	5,348
4,000	76.11	4.02	80.13	31,404	3,231	34,635	5,182	808	5,990
6,000	109.74	4.78	114.52	36,102	3,719	39,821	5,957	930	6,887
8,000	143.54	7.28	150.82	60,093	6,164	66,257	9,915	1,541	11,456
10,000	178.94	7.79	186.73	63,759	6,606	70,365	10,520	1,652	12,172
12,000	217.71	8.06	225.77	68,668	7,138	75,806	11,330	1,785	13,115
14,000	253.28	8.27	261.55	72,368	7,707	80,075	11,941	1,927	13,868
16,000	285.14	9.63	294.77	88,505	10,271	98,776	14,603	2,568	17,171
18,000	320.54	10.09	330.63	91,489	10,735	102,224	15,096	2,684	17,780
20,000	354.34	10.37	364.74	96,533	11,346	107,879	15,928	2,837	18,765

a/ Pack-out basis.

b/ Calculated from crew requirements and wage rates given in Table S-13 of the supplement.

c/ Electric power estimated at 2.5 cents per horsepower hour. Natural gas fuel estimated at 58.2 cents per 1,000 cubic feet at 1,100 Btu. per hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

d/ Costs of replacing all equipment. For equipment requirements, specifications, and unit prices, see Table S-14 of the supplement.

e/ Calculated by the following equation: C_b = \$0.41WL + \$0.28NW, where W is the width of belt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights. Galvanized woven wire or mesh belting estimated by the expression \$0.43WL.

f/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

g/ Calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on belting investment, 3 percent.

Broccoli Packaging and Total Estimated Annual Costs

The broccoli spears feed from the cooling tanks onto a wire-mesh inspection belt where defective spears are removed. Lower grade spears not conforming to grade specifications being packed are sorted and placed on the central section of the inspection conveyor. The product continues on the same belt, and hand packers pick up several spears in each hand and place them in retail cartons. Cartons from carton-forming machines move on 6-inch tracks along the packing conveyor. All packers do some grading by transferring off-grade spears or pieces to the center of the belt. Packers stationed at the end of the line also remove jams or otherwise regulate the flow of cartons. The product previously sorted out and transferred to the center of the belt, as well as any product passing the final packer, continues over the end of the conveyor and is distributed either to an institutional spear-packaging line or through a chopper. As with other hand-packed products, the labor performance standard of a packer depends on the volume and continuity of product flow over the belt and on the position of pairs of workers in relation to the beginning of the line. With a crew of eight, for example, the first two packers ordinarily should pack 15 or 16 retail cartons per minute; the next pair, 13 or 14; the third pair, 11 or 12; and the last pair of workers, 10 or 11 cartons per minute. This gives a crew average of 12 or 13 cartons per minute.[1/]

After packaging, the cartons--retail or institutional--continue to a weigh line. The weight is adjusted by adding or removing product as necessary.[2/] The carton is then transferred from the scale to a 6-inch set-off conveyor situated slightly above and between the incoming supply lines.

In sequence, the cartons continue through Prespaks, closers, and wrappers. As the cartons emerge from the wrapping machines, they are placed manually on trays and set off to skids or carts for transfer to

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1/ Based on the equation: $Y = 16.1 - 1.1X$, where Y is 10-ounce cartons packed per minute, and X is the position of <u>pairs</u> of workers from the beginning of the line. The equation is valid for values of X in the following range: $4 \leq X \leq 8$.

2/ Labor performance standards of check-weigh workers are the same as for packers.

freezing facilities. In addition to the packers and weighers, workers are required to operate and attend carton equipment and wrappers. This includes traying off cartons and supplying packaging material for equipment and workers.

Two methods may be used for packaging broccoli in institutional cartons. With Method A, mechanical carton-forming and closing equipment is used, while with Method B the cartons are formed and closed by manual means. Although equipment costs with Method B are lower than with Method A, variable costs of labor and cartons with the former method are much higher. Total season costs with Method A operations are much less costly than with Method B for the lengths of operating season ordinarily experienced in California operations. Consequently, the packaging costs synthesized are based on the use of Method A.

Broccoli not packed as spears passes over the end of the packing lines and is delivered by cross conveyors or flumes to an automatic dicing or chopping machine. Where the total volume is packed in chopped form, the broccoli is conveyed directly from the sorting operation to the chop lines (Figure 9). The broccoli is cut in small pieces no greater than 1/4 inch in diameter and is belt-elevated to an accumulating hopper supplying a straight-line, semi-automatic filler. Workers stationed around the perimeter of the revolving disc rake the chopped broccoli into pockets from which it is transferred automatically to retail or institutional cartons passing beneath. The carton equipment and filler can be adjusted for either retail or institutional carton-filling operations by use of appropriate change parts, including forming heads, carton tracks, and filling pockets. For simultaneous packaging of both container styles, separate equipment and facilities are required.

Labor requirements, including production standards and wage rates, are given in supplement Table S-15. Detailed equipment specifications, unit installed costs, and requirements reflecting the synthesis of the processes and operations discussed above are given in Table S-16 of the supplement. In both tables, the labor and equipment requirements are given in relation to container style, form of output (chopped or spears), methods used, and size of plant as measured by capacity rates of output.

Hourly variable costs, equipment replacement costs, and annual fixed charges corresponding to the crew and equipment requirements given in the supplement appear in Table 16. As with the preceding products, total season

TABLE 16

Frozen Broccoli Plants--Packaging Stages: Variable Costs, Replacement Costs, and Annual Fixed Charges in Relation to Selected Rates of Output, Styles of Pack, and Methods Used
California, 1960

Rates of output[a]	Common costs[b]	Variable costs: Labor[c]	Variable costs: Power and repairs[d]	Variable costs: Cartons and wraps	Variable costs: Total	Replacement costs: Equipment: Purchase[e]	Replacement costs: Equipment: Lease[f]	Replacement costs: Belting[g]	Replacement costs: Total	Annual fixed charges: Equipment: Purchase[h]	Annual fixed charges: Equipment: Lease[i]	Annual fixed charges: Belting[j]	Annual fixed charges: Total
pounds per hour	dollars												
		BROCCOLI SPEARS											
		Retail style											
2,000	712	21.75	1.89	45.01[k]	68.65	15,662	18,186	256	34,104	2,584	1,819	64	4,467
4,000	1,424	41.39	1.91	90.02[k]	133.32	16,062	18,186	345	34,593	2,650	1,819	86	4,555
6,000	2,492	64.40	1.96	135.03[k]	201.39	16,862	18,186	521	35,569	2,782	1,819	130	4,731
8,000	2,848	76.96	3.81	180.04[k]	260.81	32,125	36,372	688	69,185	5,301	3,637	172	9,110
10,000	3,916	101.91	3.85	225.05[k]	330.81	32,725	36,372	822	69,919	5,400	3,637	206	9,243
12,000	4,984	124.92	3.91	270.06[k]	398.89	33,725	36,372	1,043	71,140	5,565	3,637	261	9,463
14,000	6,408	160.83	3.97	315.07[k]	479.87	34,766	36,372	1,304	72,442	5,736	3,637	326	9,699
16,000	6,408	164.37	5.81	360.08[k]	530.26	49,686	54,558	1,365	105,609	8,198	5,456	341	13,995
18,000	7,476	189.32	5.87	405.10[k]	600.29	50,586	54,558	1,564	106,708	8,347	5,456	391	14,194
20,000	8,544	214.27	5.91	450.11[k]	670.29	51,186	54,558	1,757	107,501	8,446	5,456	439	14,341
		Institutional style--Method A											
2,000	--[l]	19.81	1.80	25.13[m]	46.74	14,614	17,426	352	32,392	2,411	1,743	88	4,242
4,000	--	28.83	1.80	50.25[m]	80.88	14,614	17,426	352	32,392	2,411	1,743	88	4,242
6,000	--	35.91	1.82	75.38[m]	113.11	15,014	17,426	441	32,881	2,477	1,743	110	4,330
8,000	--	48.47	2.01	100.50[m]	150.98	15,257	17,426	505	33,188	2,517	1,743	126	4,386
10,000	--	55.55	2.03	125.63[m]	183.21	15,557	17,426	572	33,555	2,567	1,743	143	4,453
12,000	--	66.17	2.05	150.75[m]	218.97	15,857	17,426	637	33,920	2,616	1,743	159	4,518
14,000	--	78.90	3.60	175.88[m]	258.38	29,396	34,852	775	65,023	4,850	3,485	194	8,529
16,000	--	89.52	3.81	201.00[m]	294.33	29,718	34,852	957	65,527	4,903	3,485	239	8,627
18,000	--	100.14	3.82	226.13[m]	330.09	29,918	34,852	1,001	65,771	4,936	3,485	250	8,671
20,000	--	109.16	3.84	251.25[m]	364.25	30,318	34,852	1,089	66,259	5,002	3,485	272	8,759
		Institutional style--Method B											
2,000	--	21.75	0.88	35.24[n]	57.87	14,614	o/	352	14,966	2,411	o/	88	2,499
4,000	--	37.85	0.91	70.48[n]	109.24	15,114	o/	475	15,589	2,494	o/	119	2,613
6,000	--	55.72	0.94	105.72[n]	162.38	15,664	o/	603	16,267	2,585	o/	151	2,736
8,000	--	71.82	1.10	140.96[n]	213.88	16,207	o/	734	16,941	2,674	o/	184	2,858
10,000	--	87.75	1.13	176.20[n]	265.08	16,757	o/	862	17,619	2,765	o/	216	2,981
12,000	--	103.85	1.16	211.44[n]	316.45	17,257	o/	972	18,229	2,847	o/	243	3,090
14,000	--	123.66	1.87	246.68[n]	372.21	31,146	o/	1,194	32,340	5,139	o/	299	5,438
16,000	--	139.76	2.04	281.91[n]	423.71	31,768	o/	1,441	33,209	5,235	o/	360	5,595
18,000	--	153.92	2.07	317.15[n]	473.14	32,268	o/	1,552	33,820	5,324	o/	388	5,712
20,000	--	171.79	2.11	352.39[n]	526.29	32,918	o/	1,715	34,633	5,431	o/	429	5,860
		CHOPPED BROCCOLI											
		Retail style											
2,000	--	11.13	2.42	45.01[k]	58.56	33,323	19,537	176	53,036	5,498	1,954	44	7,496
4,000	--	18.38	2.42	90.02[k]	110.82	33,323	19,537	176	53,036	5,498	1,954	44	7,496
6,000	--	21.92	2.47	135.03[k]	159.42	34,363	19,537	176	54,076	5,670	1,954	44	7,668
8,000	--	29.17	4.81	180.04[k]	214.02	57,288	39,074	352	96,714	9,453	3,907	88	13,448
10,000	--	34.65	4.81	225.05[k]	264.51	57,288	39,074	352	96,714	9,453	3,907	88	13,448
12,000	--	36.42	4.91	270.06[k]	311.39	59,368	39,074	352	98,794	9,796	3,907	88	13,791
14,000	--	47.55	5.01	315.07[k]	367.63	70,830	39,074	352	110,256	11,687	3,907	88	15,682
16,000	--	52.86	7.23	360.08[k]	420.17	91,566	58,611	528	150,705	15,108	5,861	132	21,101
18,000	--	58.34	7.38	405.10[k]	470.82	94,686	58,611	528	153,825	15,623	5,861	132	21,616
20,000	--	62.05	7.43	450.11[k]	519.59	95,666	58,611	528	154,805	15,785	5,861	132	21,778
		Institutional style											
2,000	--	9.19	2.33	25.13[m]	36.65	p/							
4,000	--	14.67	2.33	50.25[m]	67.25								
6,000	--	16.44	2.38	75.38[m]	94.20								
8,000	--	20.15	4.19	100.50[m]	124.84								
10,000	--	23.69	4.19	125.63[m]	153.51								
12,000	--	27.23	4.30	150.75[m]	182.28								
14,000	--	34.65	4.87	175.88[m]	215.40								
16,000	--	36.42	6.58	201.00[m]	244.00								
18,000	--	38.19	6.71	226.13[m]	271.03								
20,000	--	41.90	6.76	251.25[m]	299.91								

(Continued on next page.)

Table 16, continued.

a/ Pack-out basis.

b/ Replacement costs--scales and pans for weigh lines, all styles and forms.

c/ Calculated from crew requirements and wage rates given in Table S-15 of the supplement.

d/ Electric power estimated at 2.5 cents per horsepower hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

e/ Costs of replacing all equipment, excluding leased items. For equipment requirements, specifications, and unit prices, see Table S-16 of the supplement.

f/ Annual rental price aggregated for a 10-year period.

g/ Calculated by the following equation: C_b = \$0.41WL + \$0.28NW, where W is the width of belt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights. Galvanized woven wire or mesh belting estimated by the expression \$0.43WL.

h/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

i/ Annual rental charge--rental cost per year calculated on a 10-year basis.

j/ Calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on investment, 3 percent.

k/ 10-ounce retail cartons: 5-1/4" x 1-3/8" x 4", 0.015 solid bleach sulphate. Requirements calculated at capacities indicated plus 2 percent waste allowance. Price estimated at \$9.77 per 1,000 cartons. 10-ounce overwraps: five-color print. Price estimated at \$4.02 per 1,000 wraps.

l/ Dashes indicate included above.

m/ 2½-pound institutional cartons: 9½" x 5¼" x 2½", 0.020 solid manila, for use with mechanical carton-forming and closing equipment. Requirements calculated at capacities indicated plus 0.5 percent waste allowance. Price estimated at \$23.71 per 1,000 cartons. 2½-pound overwraps: two-color print. Price estimated at \$7.54 per 1,000 wraps.

n/ 2½-pound institutional cartons: 9½" x 5¼" x 2½", 0.017 solid manila, corner gussets, for use with manual carton-forming and closing equipment. Requirements calculated at capacities indicated plus 0.5 percent waste allowance. Price estimated at \$36.29 per 1,000 cartons. 2½-pound overwraps: two-color print. Price estimated at \$7.54 per 1,000 wraps.

o/ Does not apply.

p/ Blanks indicate included under retail style chopped broccoli. Except for wrapping, the equipment is adaptable for both retail and institutional style containers when fitted with appropriate change parts.

cost points from these data are the basis for the following planning cost equations.[1]

Broccoli spears:

$$TSC = \$5,093 + \$941R_a + \$33.424R_aH_{ra} + \$18.387R_aH_{ia} \quad (40)$$

Chopped broccoli:

$$TSC = \$4,293 + \$914R_c + \$26.199R_cH_{rc} + \$15.211R_cH_{ic} \quad (41)$$

Common equipment charges--all forms and styles:

$$TSC = \$80 + \$416R_t \quad (42)$$

Although the unit variable costs of packaging broccoli in each of its various forms are independent of the scale of plant output, annual fixed costs are not. The planning equation must therefore provide for increasing total cost as plant size increases.[2] The generalized total season or planning cost equation obtained by summation of equations (40) through (42) is:

$$TSC = \$9,466 + \$2,271R_t + \$33.424R_rH_{ra} + \$18.387R_aH_{ia} + \quad (43)$$

$$+ \$26.199R_cH_{rc} + \$15.211R_cH_{ic} \; .$$

- -

1/ TSC = total season costs, in dollars, of packaging broccoli.

R_a = plant capacity, broccoli spears, in 1,000 pounds per hour.

R_c = plant capacity, chopped broccoli, in 1,000 pounds per hour.

R_t = $R_a + R_c$ = total plant capacity, all forms of output and all styles of containers, in 1,000 pounds per hour.

R_aH_{ra} = total season volume, broccoli spears, retail cartons, in 1,000 pounds per hour.

R_aH_{ia} = total season volume, broccoli spears, institutional cartons, in 1,000 pounds per hour.

R_cH_{rc} = total season volume, chopped broccoli, retail cartons, in 1,000 pounds per hour.

R_cH_{ic} = total season volume, chopped broccoli, institutional cartons, in 1,000 pounds per hour.

2/ Plants are provided with 100-percent flexibility with respect to forms of output and container styles.

Total Broccoli Plant Costs

When the planning cost equations for the preparation and packaging operations are combined with those representing general stages and cost components developed in Section 1, total plant costs for specialized frozen broccoli plants are:[1/]

$$
\begin{aligned}
TSC_B = {} & \$25,354 + \$6,733R_t + \$16.699H + \$30.474 + \\
& + \$7.817R_rH_r + \$4.655R_iH_i + \$33.424R_aH_{ra} + \\
& + \$18.387R_aH_{ia} + \$26.199R_cH_{rc} + \$15.211R_cH_{ic} \, .
\end{aligned}
\tag{44}
$$

Frozen Snap Bean Plants

The major operations involved in handling and preparing snap beans for freezing are illustrated by the equipment layout (Figure 10).

Snap Bean Preparation and Total Annual Costs

Snap beans are classified into five size categories according to diameter.[2/] These are: No. 1--8/64 inch in diameter; No. 2--11/64 inch; No. 3--14/64 inch; No. 4--18/64 inch; and No. 5--greater than 18/64 inch. Size Nos. 1, 2, 3, and 4 are normally crosscut, while No. 5's and, to a lesser extent, No. 4's are usually sliced lengthwise and packed as French, julienne, or shoestring styles.[3/]

The field-run bins of beans are removed by fork truck from temporary storage or from the cooling room on a first-in, first-out basis. Later, the bins are placed on a portable mechanical bin dumper and emptied into a rectangular collection hopper where workers hand-fork the loose beans into feed chutes of double size graders arranged as illustrated in Figure 10. As the pods pass through the revolving sizing cylinders, they are separated into

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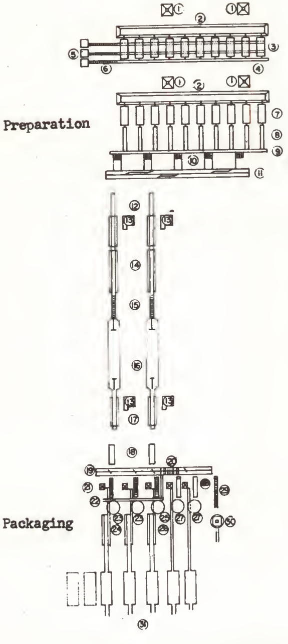
1/ See Table 9 for a summary of the planning equations for general stages and cost components.

2/ For more details, refer to U. S. Agricultural Marketing Service, United States Standards for Grades of Frozen Green Beans and Frozen Wax Beans, Effective July 5, 1954, as Amended August 25, 1954, 1954, 6p.

3/ Snap beans are also packed whole but in relatively small amounts. This analysis is limited to crosscut and sliced styles only.



LEGEND

(1) Mechanical Bin Dumpers
(2) Feed Hoppers
(3) Double Size Graders
(4) Cross Collection Conveyors
(5) Collection Bins, Sized Beans
(6) Flight Conveyors
(7) Snipper Units
(8) Inspection Belts
(9) Cross Collection Conveyors
(10) Mechanical Cutters and/or Slicers
(11) Cross Collection Conveyors
(12) Washer-Feed Conveyors
(13) Water Pressure Booster Pumps
(14) Flood-Type Wash Assembly
(15) Blanch-Feed Conveyors, Flight Type
(16) Steam Blanch Assembly
(17) Flood-Type Cooling Assembly
(18) Mesh Inspection Conveyors
(19) Cross Distribution Conveyors
(20) Flight Conveyors
(21) Carton Forming Equipment
(22) Cross Collection Conveyors
(23) Retail Carton Filler, Cuts
(24) Retail Weigh Line, Cuts
(25) Institutional Carton Filler, Cuts
(26) Institutional Weigh Line, Cuts
(27) Retail-Institutional Carton Filler, Sliced
(28) Slice-Line Feed Belts
(29) Flight Conveyors to Bulk Filler
(30) Bulk Fill Assembly, Cuts
(31) Carton Wrapping Machines, Retail and Institutional Cartons

Capacity: 5 to 6 tons per hour; approximate scale: .025" = 1'

Figure 10. Layout of a Specialized Frozen Snap Bean Line, California, 1960.

three general sizes and are deposited on cross collection conveyors for delivery to holding bins. When the holding bins are filled, they are picked up by fork truck and transferred directly or via temporary storage to the snipping process where stem ends are mechanically removed.

The graded bins of snap beans are supplied to the snipping machines in exactly the same manner as with size grading. From the collection hopper, beans are hand-forked into the snipping drum through a feed chute. The beans feed through the revolving drum equipped with agitators for constantly turning the beans end for end so that both ends fall into thousands of countersunk holes and are sheared off by blades installed along the outer perimeter of the drum. After snipping, the beans discharge onto inspection conveyors servicing each snipper. Workers, stationed on either or both sides of the inspection conveyor sort the snipped beans, hand-snip all beans missed by the machine, and remove defective pods, pieces, and foreign materials.

Crosscut beans discharge from the cutter onto a shaker-type separator from which they are deposited onto a divided cross conveyor. They are then elevated into a conventional steam blancher and flood-cooled in tanks equipped with overhead pressure or fog sprays. They are then discharged onto a wire-mesh conveyor for dewatering and further inspection. Sliced beans are conveyed through a separate blanch and cooling assembly.

Crew requirements and the labor performance standards on which they are based are shown in Table S-17 of the supplement. Detailed equipment requirements in relation to selected capacity rates of output are given in Table S-18.

Estimated variable costs per hour, equipment replacement costs, and annual fixed charges are given in Table 17. These data were used to estimate total annual costs in relation to size of plant and length of operating season. The planning equation developed from these cost points is:1/

$$TSC = \$2,963 + \$1,892R + \$9.646H + \$5.758RH. \qquad (45)$$

- -

1/ Where TSC is total season costs, in dollars, of snap bean preparation, R is plant capacity in 1,000 pounds per hour, and H is number of hours operated per season.

TABLE 17

Frozen Snap Bean Plants--Preparation Stages: Variable Costs, Replacement Costs and Annual Fixed Charges in Relation to Selected Rates of Output
California, 1960

Rates of output a/	Variable costs			Replacement costs			Annual fixed charges		
	Labor b/	Power, fuel, and repairs c/	Total	Equipment d/	Belting e/	Total	Equipment f/	Belting g/	Total
pounds per hour	dollars								
2,000	18.04	4.20	22.24	42,780	1,103	43,883	7,059	276	7,335
4,000	27.23	5.60	32.83	64,257	1,438	65,695	10,602	360	10,962
6,000	36.42	6.65	43.07	82,572	1,773	84,345	13,624	443	14,067
8,000	47.38	7.80	55.18	104,281	2,107	106,388	17,206	527	17,733
10,000	56.57	8.90	65.47	125,592	2,442	128,034	20,723	611	21,334
12,000	70.90	10.10	81.00	148,376	2,776	151,152	24,482	694	25,176
14,000	81.86	11.20	93.06	168,991	3,110	172,101	27,884	778	28,662
16,000	85.05	12.40	97.45	197,757	3,622	201,379	32,630	906	33,536
18,000	100.24	13.45	113.69	221,181	3,956	225,137	36,495	989	37,484
20,000	111.20	14.65	125.85	242,980	4,292	247,272	40,092	1,073	41,165

a/ Pack-out basis.

b/ Calculated from crew requirements and wage rates given in Table S-17 of the supplement.

c/ Electric power estimated at 2.5 cents per horsepower hour. Natural gas fuel estimated at 58.2 cents per 1,000 cubic feet at 1,100 Btu. per hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

d/ Costs of replacing all equipment. For equipment requirements, specifications, and unit prices, see Table S-18 of the supplement.

e/ Calculated by the following equation: C_b = \$0.41WL + \$0.28NW, where W is the width of belt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights. Galvanized woven wire or mesh belting estimated by the expression \$0.43WL.

f/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

g/ Calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on belting investment, 3 percent.

Snap Bean Packaging and Total Annual Costs

Crosscut snap beans may be loose frozen and packed in bulk bags or cases, or they may be frozen after packaging in conventional retail and institutional cartons. As sliced beans are not adapted to loose (IQF) freezing, they are frozen in the package.

As illustrated in Figure 10, the sliced and crosscut styles are processed by separate facilities if they are run simultaneously.1/ The carton-fill operation for both styles, however, is performed by semiautomatic fillers supplied by mechanical carton formers. After filling, the cartons are check-weighed, mechanically closed and wrapped, and trayed off to skids or carts for removal to freezing facilities. The steps involved are similar to the operations performed in the filling and packaging of Brussels sprouts and chopped broccoli and are not described fully here.

The steps in bulk packaging crosscut beans are similar to those for bulk filling lima beans. The snap beans are elevated to the bulk-fill accumulating hopper, from which they are released to trays passing beneath the filler on a powered roller conveyor. After filling, the trays are set off to a freezer cart and transferred to the freezing tunnel. Workers are required to operate the filler, set off full trays and supply empty ones, and transfer the skids to freezing tunnels. The loose-frozen trays of beans are removed from the freezing tunnel, manually dumped into cluster-breaking equipment, then moved by spiral, or screw, conveyor to a bulk-fill station for packaging in individually quick-frozen style into 50- or 60-pound bags or cases. The bulk containers are then check-weighed, closed, stenciled, and palletized for removal to cold storage.2/

As with plants processing the other vegetables thus far considered, 100-percent flexibility is provided in packaging equipment and facilities with respect to style of container and form of output.

- -

1/ For the types of plants considered in this study.

2/ Table S-19 of the supplement gives detailed crew requirements and labor standards for selected rates of output, style of container used, and form of pack. Detailed equipment specifications, capacities, unit prices, and requirements in relation to rates of output, container styles, and forms of output are given in Table S-20 of the supplement.

The planning cost equation developed from the data of Table 18 is:[1/]

$$
\begin{aligned}
TSC = {} & \$10{,}240 + \$2{,}042R_t + \$27.478R_aH_{ra} + \$15.781R_aH_{ia} + \\
& + \$27.478R_cH_{rc} + \$15.781R_cH_{ic} + \$4.750R_bH_b + \\
& + \$0.105R_tH_t \,.
\end{aligned}
\qquad (46)
$$

Total Snap Bean Plant Costs

Total plant costs for frozen snap bean processing are obtained by aggregating the planning cost equations of Section 1 with the preparation and packaging cost relationships given above.[2/] Total season costs in relation to capacity rates of output, length of operating season, and other conditions of plant operations are:

$$
\begin{aligned}
TSC_{Sb} = {} & \$25{,}604 + \$7{,}648R_t + \$16.228H + \$18.720RH + \\
& + \$7.817R_rH_r + \$4.655R_iH_i + \$4.750R_bH_b + \\
& + \$27.478R_aH_{ra} + \$15.781R_aH_{ia} + \$24.478R_cH_{rc} + \\
& + \$15.781R_cH_{ic} \,.
\end{aligned}
\qquad (47)
$$

- -

1/ TSC = total season costs, in dollars, of packaging snap beans.

R_a = plant capacity, crosscut snap beans, in 1,000 pounds per hour.

R_c = plant capacity, sliced snap beans, in 1,000 pounds per hour.

R_b = plant capacity, bulk packaged crosscut snap beans, in 1,000 pounds per hour.

$R_t = R_a + R_c + R_b$ = total plant capacity, all forms of output and all styles of containers, in 1,000 pounds per hour.

H_{ra} = number of hours operated, crosscut snap beans, retail cartons.

H_{ia} = number of hours operated, crosscut snap beans, institutional cartons.

H_{rc} = number of hours operated, sliced snap beans, retail cartons.

H_{ic} = number of hours operated, sliced snap beans, institutional cartons.

H_b = number of hours operated, crosscut snap beans, bulk containers.

H_t = number of hours operated, all forms and styles.

2/ Refer to Table 9 for planning equations representing total season costs of general stages and cost components.

TABLE 18

Frozen Snap Bean Plants--Packaging Stages: Variable Costs, Replacement Costs, and Annual Fixed Charges in Relation to Selected Rates of Output and Styles of Pack
California, 1960

Rates of output a/	Variable costs: Labor b/	Variable costs: Power and repairs c/	Variable costs: Cartons and wraps	Variable costs: Total	Replacement costs: Equipment: Purchase d/	Replacement costs: Equipment: Lease e/	Replacement costs: Belting f/	Replacement costs: Total	Annual fixed charges: Equipment: Purchase g/	Annual fixed charges: Equipment: Lease h/	Annual fixed charges: Belting i/	Annual fixed charges: Total
pounds per hour	dollars											
CUT SNAP BEANS												
Retail style												
2,000	10.96	1.95	45.01j/	57.92	17,923	18,186	138	36,247	2,957	1,819	35	4,811
4,000	21.92	1.97	90.02j/	113.91	18,123	18,186	167	36,476	2,990	1,819	42	4,851
6,000	30.77	3.91	135.03j/	169.71	19,280	18,186	226	37,692	3,181	1,819	57	5,057
8,000	36.25	3.93	180.04j/	220.22	36,246	36,372	335	72,953	5,981	3,637	84	9,702
10,000	45.27	3.96	225.05j/	274.28	36,546	36,372	379	73,297	6,030	3,637	95	9,762
12,000	52.35	5.90	270.06j/	328.31	38,560	36,372	453	75,385	6,362	3,637	113	10,112
14,000	65.25	5.91	315.07j/	386.23	42,358	36,372	526	79,256	6,989	3,637	132	10,758
16,000	72.33	7.85	360.08j/	440.26	55,896	54,558	613	111,067	9,223	5,456	153	14,832
18,000	81.35	7.88	405.10j/	494.33	57,840	54,558	679	113,077	9,544	5,456	170	15,170
20,000	88.60	7.91	450.11j/	546.62	61,438	54,558	723	116,719	10,137	5,456	181	15,774
Institutional style												
2,000	9.19	1.97	25.13k/	36.29	15,778	17,426	59	33,263	2,603	1,743	15	4,361
4,000	16.44	1.97	50.25k/	68.66	15,778	17,426	59	33,263	2,603	1,743	15	4,361
6,000	19.98	2.00	75.38k/	97.36	15,978	17,426	59	33,463	2,636	1,743	15	4,394
8,000	25.46	2.02	100.50k/	127.98	16,078	17,426	103	33,607	2,653	1,743	26	4,422
10,000	29.00	2.02	125.63k/	156.65	16,228	17,426	125	33,779	2,678	1,743	31	4,452
12,000	36.08	3.87	150.75k/	190.70	20,162	17,426	148	37,736	3,327	1,743	37	5,107
14,000	43.50	3.87	175.88k/	223.25	31,956	34,852	177	66,985	5,273	3,485	44	8,802
16,000	47.04	5.01	201.00k/	253.05	32,056	34,852	192	67,100	5,289	3,485	48	8,822
18,000	50.58	5.03	226.13k/	281.74	32,156	34,852	207	67,215	5,306	3,485	52	8,843
20,000	56.06	5.04	251.25k/	312.35	32,356	34,852	236	67,444	5,339	3,485	59	8,883
Bulk style												
2,000	13.58	0.40	5.15l/	19.13	4,193	--m/	85	4,278	692	--	21	713
4,000	15.52	0.55	10.30l/	26.37	4,193	--	85	4,278	692	--	21	713
6,000	15.52	0.65	15.46l/	31.63	4,193	--	85	4,278	692	--	21	713
8,000	21.34	0.75	20.61l/	42.70	4,193	--	85	4,278	692	--	21	713
10,000	21.34	0.90	25.76l/	48.00	4,193	--	85	4,278	692	--	21	713
12,000	25.22	1.00	30.91l/	57.13	8,386	--	170	8,556	1,384	--	43	1,427
14,000	32.98	1.10	36.06l/	70.14	8,386	--	170	8,556	1,384	--	43	1,427
16,000	32.98	1.20	41.22l/	75.40	8,386	--	170	8,556	1,384	--	43	1,427
18,000	32.98	1.30	46.37l/	80.65	8,386	--	170	8,556	1,384	--	43	1,427
20,000	38.80	1.40	51.52l/	91.72	8,386	--	170	8,556	1,384	--	43	1,427
SLICED SNAP BEANS												
Retail style												
2,000	10.96	1.95	45.01j/	57.92	29,439	19,537	59	49,035	4,857	1,954	15	6,826
4,000	21.92	1.97	90.02j/	113.91	29,439	19,537	59	49,035	4,857	1,954	15	6,826
6,000	30.77	3.91	135.03j/	169.71	30,479	19,537	59	50,075	5,029	1,954	15	6,998
8,000	36.25	3.93	180.04j/	220.22	49,436	39,074	118	88,628	8,157	3,907	30	12,094
10,000	45.27	3.96	225.05j/	274.28	49,436	39,074	118	88,628	8,157	3,907	30	12,094
12,000	52.35	5.90	270.06j/	328.31	51,516	39,074	118	90,708	8,500	3,907	30	12,437
14,000	65.25	5.91	315.07j/	386.23	62,978	39,074	118	102,170	10,391	3,907	30	14,328
16,000	72.33	7.85	360.08j/	440.26	79,746	58,611	177	138,534	13,158	5,861	44	19,063
18,000	81.35	7.88	405.10j/	494.33	82,866	58,611	177	141,654	13,673	5,861	44	19,578
20,000	88.60	7.91	450.11j/	546.62	83,846	58,611	177	142,634	13,835	5,861	44	19,740
Institutional style												
2,000	9.19	1.97	25.13k/	36.29	n/							
4,000	16.44	1.97	50.25k/	68.66								
6,000	19.98	2.00	75.38k/	97.36								
8,000	25.46	2.02	100.50k/	127.98								
10,000	29.00	2.02	125.63k/	156.65								
12,000	36.08	3.87	150.75k/	190.70								
14,000	43.50	3.87	175.88k/	223.25								
16,000	47.04	5.01	201.00k/	253.05								
18,000	50.58	5.03	226.13k/	281.74								
20,000	56.06	5.04	251.25k/	312.35								
COMMON COSTS--ALL FORMS AND STYLES												
2,000	--	0.65	--	0.65	5,214	--	847	6,061	860	--	212	1,072
4,000	--	0.69	--	0.69	5,926	--	847	6,773	978	--	212	1,190
6,000	--	0.76	--	0.76	7,035	--	871	7,906	1,161	--	218	1,379
8,000	--	0.99	--	0.99	9,640	--	1,306	10,946	1,591	--	327	1,918
10,000	--	1.14	--	1.14	10,708	--	1,307	12,015	1,767	--	327	2,094
12,000	--	1.21	--	1.21	11,859	--	1,346	13,205	1,957	--	337	2,294
14,000	--	1.45	--	1.45	14,023	--	1,531	15,554	2,314	--	363	2,677
16,000	--	1.76	--	1.76	16,780	--	2,117	18,897	2,769	--	529	3,298
18,000	--	1.83	--	1.83	17,951	--	2,167	20,118	2,962	--	542	3,504
20,000	--	1.90	--	1.90	19,070	--	2,192	21,262	3,147	--	548	3,695

(Continued on next page.)

Table 18, continued.

a/ Pack-out basis.

b/ Calculated from crew requirements and wage rates given in Table S-19 of the supplement.

c/ Electric power estimated at 2.5 cents per horsepower hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

d/ Costs of replacing all equipment, excluding leased items. For equipment requirements, specifications, and unit prices, see Table S-20 of the supplement.

e/ Annual rental price aggregated for a 10-year period.

f/ Calculated by the following equation: $C_b = \$0.41WL + \$0.28NW$, where W is the width of belt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights. Galvanized woven wire or mesh belting estimated by the expression $0.43WL.

g/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

h/ Annual rental charge--rental cost per year calculated on a 10-year basis.

i/ Calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on investment, 3 percent.

j/ 10-ounce retail cartons: 5-1/4" x 1-3/8" x 4", 0.015 solid bleach sulphate. Requirements calculated at capacities indicated plus 2 percent waste allowance. Price estimated at $9.77 per 1,000 cartons. 10-ounce overwraps: five-color print. Price estimated at $4.02 per 1,000 wraps.

k/ 2½-pound institutional cartons: 9½" x 5¼" x 2½", 0.020 solid manila, for use with mechanical carton-forming and closing equipment. Requirements calculated at capacities indicated plus 0.5 percent waste allowance. Price estimated at $23.71 per 1,000 cartons. 2½-pound overwraps: two-color print. Price estimated at $7.54 per 1,000 wraps.

l/ 55-pound bags: plain, multiwall, 1/40 wax, 6-inch tuck-in sleeve. Price estimated at $129 per 1,000 bags.

m/ Dashes indicate does not apply.

n/ Blanks indicate included under retail style sliced snap beans. Except for wrapping, the equipment is adaptable for both retail and institutional style containers when fitted with appropriate change parts.

Figure 11 shows equipment arrangement and stage organization of spinach preparation and packaging operations. Incoming spinach is shown to flow through a series of prepackaging stages, including dumping, dry cleaning, inspection, washing, blanching, and cooling. The spinach is split off into several independent processes in the packaging operation according to the size of containers or form in which it is to be marketed.

Spinach Preparation and Total Annual Costs

Spinach is hand-forked to a receiving conveyor consisting of a cleated belt with 24-inch sideboards, from which it is delivered to a flight conveyor and elevated to a wire-mesh dry-cleaning reel. Longitudinal flights installed within the reel carry the product up the cylinder walls so as to turn the leaves, creating a tumbling action that shakes out small leaves, sand and dirt clods, and other refuse. The dry-cleaning action also removes a large portion of any aphis or other insects that are present. The spinach is discharged from the cleaning cylinder and is elevated to a cross conveyor supplying the initial (dry-belt) inspection lines. Several sorters, on opposite sides of the belts, inspect the spinach and remove defects and other material.[1/]

The spinach is then picked up on a cross conveyor and distributed to a flood-type wash assembly (Figure 11). The wash assembly consists of two large rectangular tanks arranged in tandem and equipped with overhead sprays serviced by a pressure boost hydropump. As the spinach nears the end of the wash assembly, it is picked up by a wire-mesh conveyor and draper-fed into a hot-water bath or wilt tank. Preblanch wilting releases air from the cells and saturates the product so that it is distributed more uniformly on the blanch feed conveyor and draper. This increases blanching capacity and provides a more uniform blanch. The spinach feeds directly from the wilt-tank discharge draper onto a feed conveyor servicing a conventional-type steam

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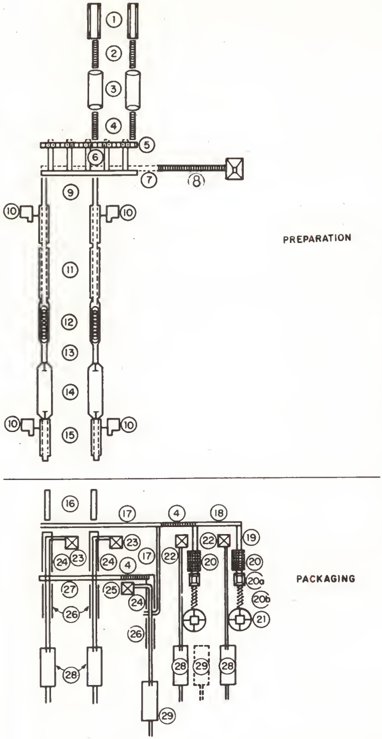
1/ Defects include grit, sand, or silt; seed heads; grass and weeds; crowns of root stubs; root stubs; and damage attributable to discolored leaves. See U. S. Production and Marketing Administration, United States Standards for Grades of Frozen Spinach, Effective October 26, 1951, 1951, 9p.



LEGEND

1. Dump Conveyor (2)
2. Flight Conveyor (2)
3. Dry-Cleaning Reel (2)
4. Flight Conveyor (4)
5. Cross Distribution Conveyor
6. Dry Inspection Belts (5)
7. Cross Conveyor
8. Waste Conveyor
9. Washer Feed Conveyor (2)
10. Water Pressure Booster Pump (4)
11. Flood-type Washer (2)
12. Wilt-tank Assembly (2)
13. Blancher Feed Conveyor (2)
14. Steam Blanch Assembly (2)
15. Flood-type Cooling Assembly (2)
16. Mesh Conveyor (2)
17. Cross Conveyor to Chop Lines
18. Conveyor to Chop Line No. 2
19. Chopper Feed Conveyor (2)
20. Choppers (2)

20A Chopper Discharge Hopper (2)

20B Feed Conveyor to Filler – Spiral Type (2)

21. Retail and Institutional Carton Fillers – Chop Lines (2)
22. Retail and Institutional Carton Forming Assembly – Chop Lines (2)
23. Retail Carton Forming Assembly – Leaf (2)
24. Inspection and Packing Belts – Leaf Lines (3)
25. Institutional Carton Forming Assembly – Leaf Line (1)
26. Weight Belts – Leaf Lines (3)
27. Cross Conveyor to Institutional Leaf Line
28. Retail Carton Wrappers (4)
29. Institutional Carton Wrappers (2)

Capacity: 5 to 6 tons per hour; approximate scale: .025" = 1'

Figure 11. Layout of a Specialized Frozen Spinach Line, California, 1960.

blancher. The blanching time varies from 1 to $2\frac{1}{2}$ minutes, depending on the blanch load and surrounding temperature in the processing plant. When the spinach is prewilted as assumed here, the time of blanch drops to an average of 1 to $1\frac{1}{2}$ minutes.1/ After blanching, the spinach moves directly to a hydrocooling tank equipped with a battery of pressure or fog sprays.

A synthesis of crew and equipment requirements and costs is given in Table S-21 of the supplement.

Variable costs and fixed equipment costs for the preparation stages discussed above were calculated by applying appropriate cost rates to the crew and equipment requirements given in Table S-21. These costs, related to selected capacity output rates, are summarized in Table 19 and are the basis for the planning equation:

$$TSC = \$3{,}547 + \$702R + \$7.975H + \$3.084RH. \qquad (48)$$

Spinach Packaging and Total Annual Costs

Spinach is packed in two forms--whole leaves and chopped. From the cooling tank, the product moves to a wire-mesh conveyor for dewatering and inspection. Dewatering is accomplished by gravity drainage through the mesh belting and by a free-floating roller-compressor unit.2/ Sorting workers stationed on both sides of the inspection conveyor fluff the spinach and sort out defects, including off-color leaves, woody stems, and foreign material not removed in earlier cleaning and inspection stages. The sorters also group the product into piles that are convenient for the packers to grasp and place in appropriate cartons.

Leaf spinach is hand-packed into retail or institutional cartons according to the quality of the product or planned production categories. The packing line is usually a continuation of the inspection belt, with carton runs on either side. The packers grasp piles of spinach--previously grouped and formed by the inspection workers--and place them in cartons moving

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1/ Cost and requirements of blanching equipment and operation synthesized in this study are based on a $1\frac{1}{2}$-minute blanching time.

2/ The compressor unit considered here is custom built. In several plants, the compressor is a series of parallel rollers resting on the conveyors, while in other plants the unit consists of a pair of revolving, water-ballasted, airplane-type inner tubes.

TABLE 19

Frozen Spinach Plants--Preparation Stages: Variable Costs, Replacement Costs and Annual Fixed Charges in Relation to Selected Rates of Output California, 1960

Rates of output[a]	Variable costs			Replacement costs			Annual fixed charges		
	Labor[b]	Power, fuel, and repairs[c]	Total	Equipment[d]	Belting[e]	Total	Equipment[f]	Belting[g]	Total
pounds per hour	dollars								
2,000	12.90	3.26	16.16	28,007	1,127	29,134	4,621	282	4,903
4,000	16.44	3.57	20.01	31,460	1,900	33,360	5,191	475	5,666
6,000	19.98	4.29	24.27	34,624	2,439	37,063	5,713	610	6,323
8,000	25.46	6.58	32.04	61,107	3,679	64,786	10,083	920	11,003
10,000	29.00	7.09	36.09	63,200	4,218	67,418	10,428	1,055	11,483
12,000	39.96	7.35	47.31	66,206	4,757	70,963	10,924	1,189	12,113
14,000	45.44	7.51	52.95	67,748	4,782	72,530	11,178	1,196	12,374
16,000	48.98	9.85	58.83	85,758	6,536	92,294	14,150	1,634	15,784
18,000	52.52	10.30	62.82	88,230	7,075	95,305	14,558	1,769	16,327
20,000	58.00	10.51	68.51	90,307	7,090	97,407	14,901	1,773	16,674

a/ Pack-out basis.

b/ Calculated from crew requirements and wage rates given in Table S-21 of the supplement.

c/ Electric power estimated at 2.5 cents per horsepower hour. Natural gas fuel estimated at 58.2 cents per 1,000 cubic feet at 1,100 Btu. per hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

d/ Costs of replacing all equipment. For equipment requirements, specifications, and unit prices, see Table S-21 of the supplement.

e/ Calculated by the following equation: $C_b = \$0.41WL + \$0.28NW$, where W is the width of belt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights. Galvanized woven wire or mesh belting estimated by the expression $0.43WL.

f/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent.

g/ Calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on belting investment, 3 percent.

directly in front of them. As with other products that are hand-packed, the labor performance standard of a packer depends on the volume and continuity of product flow over the belt and on the position of the worker in relation to the beginning of the line. With a crew of eight, for example, the first two packers ordinarily should pack 28 to 30 retail cartons per minute; the next pair, 18 to 20 cartons; the third pair, 15 to 17 cartons; and the last pair of workers, 13 to 15 cartons per minute. This gives an overall average for the crew of 18 to 20 cartons per minute.1/

The filled cartons are conveyed to the check-weigh line where workers weigh each carton and remove or add product as necessary to meet weight specifications.2/ The weighed cartons are then set off and conveyed to a mechanical carton closer. The wrapping operation follows, after which the cartons are manually set off in trays and placed in carts for transfer to the freezing facilities.

Two methods--designated as Methods A and B--are used for packing leaf spinach in institutional cartons. With Method A, mechanical equipment is used in forming and closing cartons, but in Method B these operations are performed manually. Although equipment costs with Method B are lower than with Method A, variable costs are so much higher with Method B that it is the most costly method over all ranges of output and length of operating season considered; Method A, therefore, is used in this analysis.3/

The spinach not packed in leaf style by manual means passes over the end of the retail or institutional packing belts (Figure 11) and is delivered by cross and feed conveyors to an automatic dicing or chopping machine. The spinach is discharged from the chopper into a collection hopper, from which it is moved by spiral conveyor to the fill hopper of

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1/ A generalized expression--developed from data obtained in time studies--for estimating the number of pounds packed per packer hour is given by the equation: $Y = 1{,}013.20 - 75.93X$, where Y is pounds of leaf spinach packed in retail cartons per worker hour, and X is the line position of the worker. This equation is valid only for values of X in the range: $4 \leq X \leq 10$.

2/ The crew requirements for any given volume of output are estimated by the following equation: $Y = 556.80 - 28.38X$, where Y is pounds of leaf spinach weighed in retail cartons per weigher-hour, and X is the line position of the workers (valid for values of X in the range: $4 \leq X \leq 16$).

3/ Costs with each method are given in Table 20.

a plunger-type filler.[1] Cartons are check-weighed, closed, wrapped, and trayed off in the conventional manner.

Detailed crew and equipment requirements for spinach packaging operations are given in the supplement.[2]

Costs related to the packaging of spinach for freezing are summarized in Table 20. These costs were estimated by applying appropriate cost rates to the equipment and crew requirements given in supplement Tables S-22 and S-23. In developing a planning cost function for packaging spinach, consideration must be given to the proportions packed in the various forms of output--leaf and chopped--and styles of containers. To pack any given volume of daily receipts in one or more forms or container styles, plants must be designed to operate with considerable flexibility. Frozen spinach plants synthesized in this study, like the plants processing the other vegetables considered, are provided with packaging equipment and facilities adequate for handling the total volume of receipts in any form and style. Total annual packaging costs estimated on this basis are:[3]

$$TSC = \$9,383 + \$2,147R_t + \$30.160R_aH_{ra} + \$17.738R_aH_{ia} + \$24.725R_cH_{rc} + \$14.259R_cH_{ic} + \$2.390RH \,. \quad (49)$$

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1/ The plants synthesized in this study specify use of a spiral conveyor. However, many plants processing spinach in chopped form use product pumps to supply the product to the fillers.

2/ Supplement Table S-22 gives crew requirements, labor performance standards, and wage rates. Supplement Table S-23 gives equipment requirements, specifications, and unit prices in relation to capacity output rates for the various container styles and forms of output considered.

3/ TSC = total season costs, in dollars, of packaging spinach.

R_a = plant capacity, leaf spinach, in 1,000 pounds per hour.

R_c = plant capacity, chopped spinach, in 1,000 pounds per hour.

$R_t = R_a + R_c$ = total plant capacity, all forms of output and all styles of containers, in 1,000 pounds per hour.

H_{ra} = number of hours operated, leaf spinach, retail cartons.

H_{ia} = number of hours operated, leaf spinach, institutional cartons.

H_{rc} = number of hours operated, chopped spinach, retail cartons.

H_{ic} = number of hours operated, chopped spinach, institutional cartons.

H = number of hours operated, all forms and styles.

TABLE 20

Frozen Spinach Plants--Packaging Stages: Variable Costs, Replacement Costs, and Annual Fixed Charges in Relation to Selected Rates of Output, Styles of Pack, and Methods Used
California, 1960

Rates of output[a]	Variable costs																						
				Leaf spinach												Chopped spinach							
	Common costs[b]			Retail style				Institutional style								Retail style				Institutional style			
								Method A				Method B											
	Labor[c]	Power and repairs[d]	Total	Labor[c]	Power and repairs[d]	Cartons and wraps[e]	Total	Labor[c]	Power and repairs[d]	Cartons and wraps[f]	Total	Labor[c]	Power and repairs[d]	Cartons and wraps[g]	Total	Labor[c]	Power and repairs[d]	Cartons and wraps[e]	Total	Labor[c]	Power and repairs[d]	Cartons and wraps[f]	Total
pounds per hour	dollars																						
2,000	5.31	0.14	5.45	18.21	1.57	45.01	64.79	14.67	1.48	25.13	41.28	21.75	0.77	35.24	57.76	9.63	1.02	45.01	55.39	9.36	0.94	25.13	35.43
4,000	10.62	0.19	10.81	32.54	1.58	90.02	124.14	25.29	1.49	50.25	77.03	36.08	0.79	70.48	107.35	13.07	1.11	90.02	104.20	11.13	0.94	50.25	62.32
6,000	14.16	0.25	14.41	44.93	1.60	135.03	181.56	32.37	1.50	75.38	109.25	50.41	0.81	105.72	156.94	13.07	1.22	135.03	149.32	11.13	1.02	75.38	87.53
8,000	19.47	0.39	19.86	59.26	3.15	180.04	242.45	43.16	1.83	100.50	145.49	66.51	1.10	140.96	208.57	20.32	2.18	180.04	202.54	16.61	1.40	100.50	118.51
10,000	23.01	0.44	23.45	73.59	3.18	225.05	301.82	50.24	1.84	125.63	177.71	78.90	1.11	176.20	256.21	22.26	2.30	225.05	249.61	16.61	1.48	125.63	143.72
12,000	28.32	0.50	28.82	85.98	3.20	270.06	359.24	57.32	1.84	150.75	209.91	93.23	1.13	211.44	305.85	22.26	2.42	270.06	294.74	18.38	1.48	150.75	170.61
14,000	33.63	0.60	34.23	111.27	3.21	315.07	429.55	71.82	3.00	175.88	250.70	107.56	1.61	246.68	355.85	28.08	2.42	315.07	345.57	22.26	2.00	175.88	200.14
16,000	37.17	0.70	37.87	114.81	4.77	360.08	479.66	80.67	3.38	201.00	285.05	125.43	2.07	281.91	409.41	33.39	3.44	360.08	396.91	25.80	2.45	201.00	229.25
18,000	42.48	0.75	43.23	130.91	4.80	405.10	540.81	87.75	3.38	226.13	317.26	139.76	2.12	317.15	459.03	35.33	3.52	405.10	443.95	25.80	2.45	226.13	254.38
20,000	46.02	0.85	46.87	147.01	4.85	450.11	601.97	96.77	3.41	251.25	351.43	154.09	2.14	352.39	508.62	37.27	3.64	450.11	491.02	27.74	2.62	251.25	281.61

Rates of output[a]	Replacement costs																				
				Leaf spinach												Chopped spinach, retail and institutional styles					
	Common costs[h]			Retsil style				Institutional style								Common costs[l]				Special equipment[m]	
								Method A				Method B									
				Equipment				Equipment				Equipment				Equipment					
	Equipment[i]	Belting[j]	Total	Purchase[i]	Lease[k]	Belting[j]	Total	Purchase[i]	Lease[k]	Belting[j]	Total	Purchase[i]	Lease	Belting[j]	Total	Purchase[i]	Lease[k]	Belting[j]	Total	Retail	Institutional
	dollars																				
2,000	2,656	236	2,892	14,378	13,277	79	27,734	12,550	13,279	221	26,050	12,650	n/	246	12,896	3,820	19,537	79	23,446	14,650	12,905
4,000	3,568	295	3,863	14,578	13,277	118	27,973	12,650	13,279	246	26,175	12,900		308	13,208	3,820	19,537	79	23,446	16,343	12,905
6,000	4,658	354	5,012	14,978	13,277	197	28,452	12,750	13,279	271	26,300	13,150		369	13,519	3,820	19,537	79	23,446	18,668	14,598
8,000	7,136	590	7,726	29,156	26,554	236	55,946	15,858	13,279	492	29,629	16,358		615	16,973	7,640	39,074	315	47,029	32,686	16,368
10,000	8,226	649	8,875	29,656	26,554	335	56,545	16,058	13,279	541	29,878	16,558		664	17,222	7,640	39,074	315	47,029	35,011	18,061
12,000	9,316	708	10,024	29,956	26,554	394	56,904	16,058	13,279	541	29,878	16,858		738	17,596	7,640	39,074	315	47,029	37,336	18,061
14,000	11,162	886	12,048	30,156	26,554	433	57,143	25,800	26,558	615	52,973	26,500		787	27,287	7,640	39,074	315	47,029	37,336	28,346
16,000	12,906	1,063	13,969	44,484	39,831	502	84,817	29,679	26,558	812	57,049	32,679		1,181	33,860	11,460	58,611	708	70,779	51,986	31,837
18,000	13,974	1,063	15,037	44,934	39,831	590	85,355	29,679	26,558	812	57,049	33,129		1,661	34,790	11,460	58,611	708	70,779	53,679	31,837
20,000	15,586	1,328	16,914	45,894	39,831	649	86,374	30,129	26,558	923	57,610	33,429		1,734	35,163	11,460	58,611	708	70,779	56,004	35,223

(Continued on next page)

Tahle 20, continued.

Rates of output a/	Annual fixed charges																					
	Leaf spinach																Chopped spinach, retail and institutional styles					
	Common costs h/			Retail style				Institutional style									Common costs l/				Special equipment m/	
								Method A				Method B										
				Equipment				Equipment				Equipment					Equipment					
	Equipment o/	Belting p/	Total	Purchase o/	Lease q/	Belting p/	Total	Purchase o/	Lease q/	Belting p/	Total	Purchase o/	Lease	Belting p/	Total		Purchase o/	Lease q/	Belting p/	Total	Retail	Institutional
pounds per hour	dollars																					
2,000	438	59	497	2,372	1,328	20	3,720	2,071	1,328	55	3,454	2,087	n/	62	2,149		630	1,954	20	2,604	2,417	2,129
4,000	589	74	663	2,405	1,328	20	3,763	2,087	1,328	62	3,477	2,129		77	2,206		630	1,954	20	2,604	2,697	2,129
6,000	769	89	858	2,471	1,328	49	3,848	2,104	1,328	68	3,500	2,170		92	2,262		630	1,954	20	2,604	3,080	2,409
8,000	1,177	148	1,325	4,811	2,655	59	7,525	2,617	1,328	123	4,068	2,699		154	2,853		1,261	3,907	79	5,247	5,393	2,701
10,000	1,357	162	1,519	4,893	2,655	84	7,632	2,650	1,328	135	4,113	2,732		166	2,898		1,261	3,907	79	5,247	5,777	2,980
12,000	1,537	177	1,714	4,943	2,655	99	7,697	2,650	1,328	135	4,113	2,782		185	2,967		1,261	3,907	79	5,247	6,160	2,980
14,000	1,842	222	2,064	4,976	2,655	108	7,739	4,257	2,656	154	7,067	4,373		197	4,570		1,261	3,907	79	5,247	6,160	4,677
16,000	2,129	266	2,395	7,340	3,983	126	11,449	4,897	2,656	203	7,756	5,392		295	5,687		1,891	5,861	177	7,929	8,578	5,253
18,000	2,306	266	2,572	7,414	3,983	148	11,545	4,897	2,656	203	7,756	5,466		415	5,881		1,891	5,861	177	7,929	8,857	5,253
20,000	2,572	332	2,904	7,573	3,983	162	11,718	4,971	2,656	231	7,858	5,516		434	5,950		1,891	5,861	177	7,929	9,241	5,812

a/ Pack-out basis.

h/ Inspection labor inputs, all styles of pack.

c/ Calculated from crew requirements and wage rates given in Table S-22 of the supplement.

d/ Electric power estimated at 2.5 cents per horsepower hour. Repairs estimated at 0.5 percent of replacement cost per 100 hours' operation, including mechanics' wages and supplies.

e/ 10-ounce retail cartons: 5-1/4" x 1-3/8" x 4", 0.015 solid bleach sulphate. Requirements calculated at capacities indicated plus 2 percent waste allowance. Price estimated at \$9.77 per 1,000 cartons. 10-ounce overwraps: five-color print. Price estimated at \$4.02 per 1,000 wraps.

f/ $2\frac{1}{2}$-pound institutional cartons: $9\frac{1}{2}$" x $5\frac{1}{4}$" x $2\frac{1}{2}$", 0.020 solid manila for use with mechanical carton-forming and closing equipment. Requirements calculated at capacities indicated plus 0.5 percent waste allowance. Price estimated at \$23.71 per 1,000 cartons. $2\frac{1}{2}$-pound overwraps: two-color print. Price estimated at \$7.54 per 1,000 wraps.

g/ $2\frac{1}{2}$-pound institutional cartons: $9\frac{1}{2}$" x $5\frac{1}{4}$" x $2\frac{1}{2}$", 0.017 solid manila, corner gussets, for use with manual carton-forming and closing equipment. Requirements calculated at capacities indicated plus 0.5 percent waste allowance. Price estimated at \$36.29 per 1,000 cartons. $2\frac{1}{2}$-pound overwraps: two-color print. Price estimated at \$7.54 per 1,000 wraps.

h/ Includes costs of inspection and packing conveyors and scales and pans for weigh lines.

i/ Costs of replacing all equipment, excluding leased items. For equipment requirements, specifications, and unit prices, see Table S-23 of the supplement.

j/ Calculated by the following equation: $C_b = \$0.41WL + \$0.28NW$, where W is the width of helt in inches, L is the length of conveyor frame in feet, and N is the number of cleats or flights. Galvanized woven wire or mesh helting estimated by the expression \$0.43WL.

k/ Annual rental price aggregated for a 10-year period.

l/ Includes costs of distribution conveyors, chopper, and adaptable carton-forming and closing equipment.

m/ Costs of equipment unique with chopped retail and institutional styles of packaging.

n/ Blanks indicate does not apply.

o/ Calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated halance); and fixed repairs and maintenance, 1.5 percent.

p/ Calculated as 25 percent of helting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on investment, 3 percent.

q/ Annual rental charge--rental cost per year calculated on a 10-year hasis.

Total Spinach Plant Costs

Total plant costs for processing frozen spinach are obtained by aggregating the planning cost equations for the general stages and cost components developed in Section 1 and from those representing costs of preparation and packaging given above.[1] Total season costs for specialized frozen spinach plants in relation to rate of output, length of operating season, and other conditions of plant operation are:

$$\begin{aligned} TSC = \$25{,}484 &+ \$6{,}424R + \$14.861H + \$17.888RH + \\ &+ \$7.817R_rH_r + \$4.655R_iH_i + \$30.160R_aH_{ra} + \\ &+ \$17.738R_aH_{ia} + \$24.725R_cH_{rc} + \$14.259R_cH_{ic} . \end{aligned} \tag{50}$$

3. Economies of Scale in Specialized Single-Product Plants

Planning cost equations developed in Sections 1 and 2 of Part III are summarized in Table 21. The stage and cost component groupings for which planning costs were calculated are identified for each product in the first column of the table, while each of the remaining columns relates to a variable used in their derivation. Part A of the table gives planning cost equations for the combined costs of general stages and cost components developed in Section 1, and Part B gives those for the combined costs of preparation and packaging operations analyzed in Section 2. Part C gives planning cost equations for the total plant operation for each of the six vegetables considered. In the discussions that follow, these equations are used to illustrate the effect of hours operated per season and plant size on total and average planning costs.

Economies Related to Scale of Plant and Length of Operating Season

A basic problem in studies of economies of scale is the definition of "scale." In the simple case of a single-product, single-plant firm, scale may be measured in terms of physical rate of output. Increasing difficulties are encountered as more complex situations are considered, such as multiplant

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1/ For details, refer to Table 9.

TABLE 21

Summary of Planning Cost Equations Representing Total Annual Costs in Specialized Frozen Vegetable Plants
California, 1960

Cost category	Variables a/														
	Constant term	R	H	RH	$RH\bar{p}$	R_rH_r	R_iH_i	R_bH_b	R_aH_{ra}	R_aH_{ia}	R_cH_{rc}	R_cH_{ic}	P_1RH	P_2RH	P_3RH
	coefficients in dollars														
General stages and cost components b/															
Broccoli	12,454	3,658	6.727	12.674	c/	7.817	4.655								
Brussels sprouts	12,274	3,692	6.277	12.769		7.817	4.655								
Snap beans	12,401	3,714	6.582	12.857		7.817	4.655								
Lima beans	12,554	3,575	6.886	12.414		7.817	4.655								
Green peas	12,554	3,575	6.886	12.414		7.817	4.655								
Spinach	12,554	3,575	6.886	12.414		7.817	4.655								
Preparation and packaging costs d/															
Broccoli	12,900	3,075	9.972	17.800					33.424	18.387	26.199	15.211			
Brussels sprouts	10,863	2,467	14.050	2.760	0.116	27.351	15.679						0.169	0.104	0.074
Snap beans	13,203	3,934	9.646	5.863				4.750	27.478	15.781	27.478	15.781			
Lima beans	7,792	1,402	19.522	3.175	0.116	24.747	14.492	4.582							
Green peas	7,521	1,399	19.666	4.497	0.218	24.747	14.492	4.582							
Spinach	12,930	2,849	7.975	5.474					30.160	17.738	24.725	14.259			
Total plant costs e/															
Broccoli	25,354	6,733	16.699	30.474		7.817	4.655		33.424	18.387	26.199	15.211			
Brussels sprouts	23,137	6,159	20.327	15.529	0.116	35.168	20.334						0.169	0.104	0.074
Snap beans	25,604	7,648	16.228	18.720		7.817	4.655	4.750	27.478	15.781	27.478	15.781			
Lima beans	20,346	4,977	26.408	15.589	0.116	32.564	19.147	4.582							
Green peas	20,075	4,974	26.552	16.911	0.218	32.564	19.147	4.582							
Spinach	25,484	6,424	14.861	17.888		7.817	4.655		30.160	17.738	24.725	14.259			

a/ Variables are defined as follows:

R = plant capacity in 1,000 pounds per hour, pack-out basis.

H = total number of hours operated per season.

RH = total season volume in 1,000 pounds per hour.

$RH\bar{p}$ = manual grade-out percentage ($\bar{p}$) multiplied by total season volume.

R_rH_r = total season volume packed in retail cartons of lima beans, green peas, and Brussels sprouts. Volume cased per season in 24/10-ounce cases, all products.

R_iH_i = total season volume packed in institutional cartons of lima beans, green peas, and Brussels sprouts. Volume cased per season in 12/2½-pound cases, all products.

R_bH_b = total season volume packed in bulk bags or cases of lima beans, green peas, and snap beans.

R_aH_{ra} = total season volume packed in retail cartons of broccoli spears, crosscut snap beans, and leaf spinach.

R_aH_{ia} = total season volume packed in institutional cartons of broccoli spears, crosscut snap beans, and leaf spinach.

R_cH_{rc} = total season volume packed in retail cartons of chopped broccoli, sliced snap beans, and chopped spinach.

R_cH_{ic} = total season volume packed in institutional cartons of chopped broccoli, sliced snap beans, and chopped spinach.

P_1RH = total season volume of size No. 2 Brussels sprouts.

P_2RH = total season volume of size No. 3 Brussels sprouts.

P_3RH = total season volume of size No. 4 Brussels sprouts.

b/ Includes casing, variable water inputs, freezing and first month's storage, fork-truck transportation, management and general labor costs, office and bookkeeping costs, building costs, and miscellaneous equipment and costs. For details, refer to Part III, Section 1, of this study.

c/ Blanks indicate does not apply.

d/ For details of the analysis of preparation and packaging costs, refer to Part III, Section 2, of this study.

e/ Aggregation of the planning cost equations for each product given in the above categories.

output of a single product in a given firm, multiple products in a given single-plant firm, horizontal integration of several disparate lines of production in a single firm, or vertical integration of several successive stages of production, processing, and marketing in a single firm.

Other considerations are the costs of raw product assembly and distribution of finished goods. Assembly costs may be particularly important with agricultural processing activities, as farm production may occur over a wide area, with increasing costs of assembly as plant size and raw product requirements increase.

Only the simplest empiric model is considered here. It involves single-plant, single-product firms, with scale defined in terms of physical rate of output, and multiple-product plants, with scale measured in terms of the aggregate physical output rate of products produced simultaneously. The analysis also is limited to plant costs and does not reflect the effects of increasing unit assembly costs as plant capacity rate increases.

Within the above limitations, the effect of size of plant as measured by capacity output rate and hours operated per season on total and average planning costs is illustrated in Figures 12 and 13 for plants specialized in processing each of the six vegetables studied. The cost curves presented are based on specific values of the variables of the individual planning equations (Table 21) as given in the panels for each product.[1/] The selection of other values for these variables, although affecting the level of costs represented, would not materially affect the relationships shown.

A chief characteristic of the total cost planning curves shown in Figure 12 is their linearity with respect to capacity output rates and lengths of operating season. This characteristic can be traced to two methods of output variation normally used in processing these vegetables. First, increases in plant capacity are obtained primarily through replication of identical or similar types of equipment and crew organizations. This means there is little or no intensification in the use of equipment and facilities or change in the proportions of inputs used. Total cost, therefore, tends

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1/ For example, the cost curves representing total and average planning costs in specialized broccoli plants are based on a season pack-out consisting of 60 percent in retail cartons of spears, 15 percent in retail cartons of chopped, 20 percent in institutional cartons of spears, and 5 percent in institutional cartons of chopped.

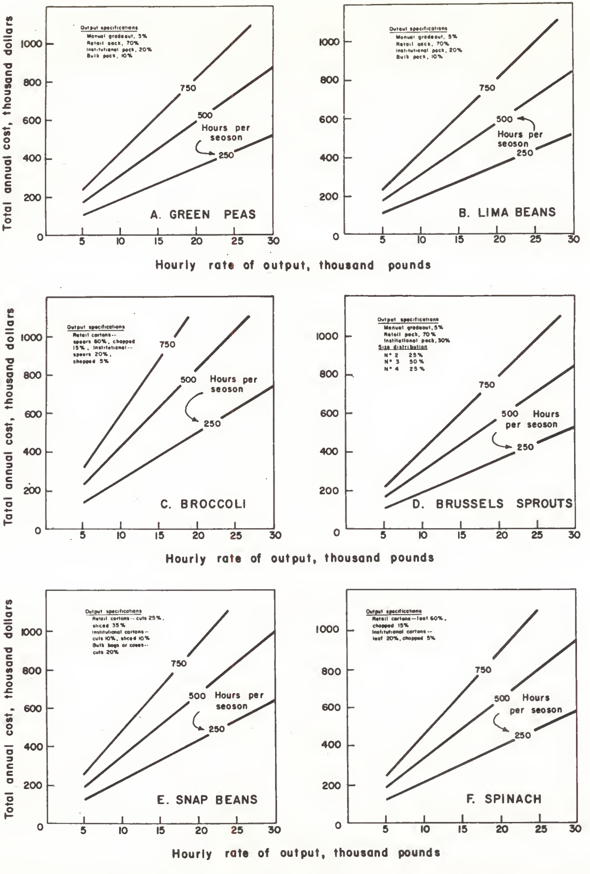

Figure 12. Total Annual Planning Costs of Processing Selected Vegetables by Freezing in Relation to Capacity Output Rate per Hour, California, 1960.

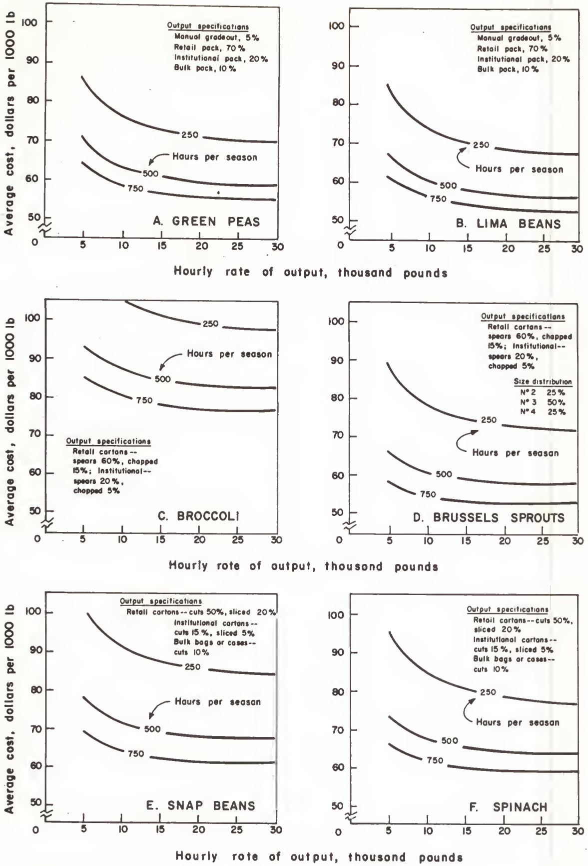

Figure 13. Average Planning Costs of Processing Selected Vegetables by Freezing in Relation to Capacity Output Rate per Hour, California, 1960.

to increase linearly with increases in plant capacity. Second, total output per season for any given plant may be varied by operating the plant at its normal capacity and varying the number of hours worked per day or week. In this case, the uniform level of intensification in the use of plant and facilities produces a linear variation in total season cost as hours operated per season at a given rate are varied.

Several general characteristics of the average cost relationships illustrated in Figure 13 are noteworthy. First, with any given pattern of daily operating hours and length of season, total season hours are fixed, and differences in total season volume necessarily involve changes in scale of plant as measured by planned capacity output rate. Each point on a particular unit planning cost curve in Figure 13, therefore, represents unit cost with a different plant. The decreasing unit cost as plant size increases results from more effective utilization of supervision and other partially fixed labor inputs and equipment and the introduction of various cost-reducing techniques in the larger plants. Second, plant capacity rates necessary to achieve any given season volume decrease as hours of operation per season increase. As planned capacity rate with a fixed season volume decreases, investment cost and the corresponding annual fixed charge are smaller and unit fixed costs are lower. As planned capacity is decreased, however, some of the cost advantages of increased scale are lost. Thus, unit planning costs vary with both length of season and size of plant, and efficient organization of plant operations calls for balancing the net cost effects of size of plant and operating hours.1/

The nature of unit planning cost variation discussed above and illustrated in Figure 13 is demonstrated in quantitative terms in Table 22, which shows that rates of reduction in unit costs with increased size are relatively uniform among the six vegetables studied. For example, with plants operating 500 hours per season and with a capacity output rate of 5,000 pounds per hour, the rate of reduction in unit planning cost per 1,000 pounds added capacity ranges from a low of $2.56 per 1,000 pounds in specialized

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1/ The least-cost combination of hours and rates for any given season volume is obtained by minimizing the planning equations representing total annual costs for plants processing each product, subject to appropriate restrictions on cost and productivity rates as affected by hours operated per day. For more detailed discussion, see French, Sammet, and Bressler, op. cit., pp. 684-698.

TABLE 22

Frozen Vegetable Plants: Rates of Reduction in Unit Planning Costs in Relation to Increased Plant Capacity and Length of Season California, 1960

Rates of reduction	Lima beans[a]	Green peas[a]	Brussels sprouts[b]	Broccoli[c]	Snap beans[d]	Spinach[e]
	dollars per thousand pounds					
Per 1,000 pounds added plant capacity in plants of:[f]						
5,000 pounds per hour	2.63	2.62	2.65	2.68	2.66	2.56
10,000 pounds per hour	0.66	0.65	0.66	0.67	0.66	0.64
20,000 pounds per hour	0.17	0.17	0.17	0.17	0.17	0.16
	cents per thousand pounds					
Per added hour of operation per season in seasons of:[g]						
250 hours	11.22	11.15	13.63	14.94	16.30	13.42
500 hours	2.80	2.79	3.41	3.74	4.08	3.36
1,000 hours	0.71	0.69	0.85	0.93	1.02	0.84

a/ Calculated on the basis of 5 percent manual grade-out, 70 percent packed in retail cartons, 20 percent in institutional cartons, and 10 percent in bulk bags or cases.

b/ Calculated on the basis of an average size distribution of sprouts of 25 percent size No. 2, 50 percent size No. 3, and 25 percent size No. 4. Pack-out assumed to be 70 percent in retail cartons and 30 percent in institutional cartons.

c/ Calculated on the basis of 60 percent packed as retail spears, 15 percent retail chopped, 20 percent institutional spears, and 5 percent institutional chopped.

d/ Calculated on the basis of 25 percent retail cut, 35 percent retail sliced, 10 percent institutional cut, 10 percent institutional sliced, and 20 percent bulk cut.

e/ Calculated on the basis of 60 percent retail leaf, 15 percent retail chopped, 20 percent institutional leaf, and 5 percent institutional chopped.

f/ Applies to plants operating 500 hours per season.

g/ Applies to plants of 10,000-pounds-per-hour capacity output rate.

frozen spinach plants to a high of $2.66 per 1,000 pounds in specialized frozen broccoli plants. With plants of 10,000 pounds hourly capacity--length of season remaining at 500 hours--average cost reduction per 1,000 pounds added capacity ranges from 64 cents to 66 cents in frozen spinach and broccoli plants, respectively.

The rates of reduction in average costs as length of season increases and the conditions for which they are calculated are also summarized in Table 22. The table indicates substantial reductions in unit cost as length of season in a given plant is increased. Economies associated with an increased number of operating hours, however, become less important for seasons in excess of 750 hours. For example, with plants of 10,000 pounds hourly capacity and with a season of 250 hours, the rate of reduction in average planning cost ranges from a low of 11.22 cents per 1,000 pounds processed per added hour of operation per season for specialized green pea plants to a high of 16.3 cents per 1,000 pounds per added hour of operation in specialized frozen snap bean plants. When the operating season is increased to 1,000 hours--output capacity rate remaining the same--unit cost reduction per added hour of operation ranges from 0.69 cent to 1.02 cents per 1,000 pounds processed in specialized frozen pea and snap bean plants, respectively.

Figure 13 and Table 22 indicate that substantial economies can be realized as size of plant and hours of operation per season are increased. Much of the potential savings, however, cannot be attained in some vegetable processing areas because of the short harvest season. In some situations, relief may be available through processing other products maturing in other periods and using the same types of equipment. An analysis of the economies that may be achieved by multiple use of equipment and processing facilities for different products maturing in different periods follows in Part IV.

Problems of Flexibility

One of the more important problems in processing vegetables for freezing is how to adjust economically to large fluctuations in daily volume of product during the operating season as well as to variations in the proportions packed in the various size containers, product forms, and grades.

Two types of adjustment to variations in daily volume are used. Hours of daily operation may be varied and the plant processing facilities operated

at their most efficient rate of output with little change in cost rates except where overtime or shift differential payments are required. With a large reduction in daily volume relative to total plant capacity, labor force may be reduced and the plant operated at less than capacity. Reduction in the proportion of plant capacity used may be particularly appropriate if collective bargaining agreements or the maintenance of satisfactory labor relations require that workers be paid for a minimum number of hours per day.

Large fluctuations in the volume of product received, as well as daily variation in the proportions which must be packed in various size containers, forms, and grades, require plants designed to operate with some degree of flexibility. This has been provided in the design of plants synthesized in this study. For example, inclusion of space and facilities for temporary storage at the receiving point provides some insurance against hour-to-hour fluctuations in plant receipts. Also, large variations in the proportions packed in the various size containers, forms, and grades are allowed for by providing filling and packaging equipment capable of handling total plant capacity in any one of the forms and styles appropriate for the commodity involved. Moreover, standards on which the planning cost equations for specific stages and components were synthesized are themselves averages. Some variation around production standards used may be expected in response to temporary changes in plant output levels and may contribute to plant flexibility.

Comparison of costs as developed above with costs in plants lacking provision for flexibility in output rate, forms, and grades will indicate the extent to which costs are affected by incorporation of this feature in the plant designs used in the study. Calculations for the constant-rate plants may be made easily by adjusting the results already given for deletion of special equipment required to provide flexibility. This involves adjustments in annual fixed charges for filling and casing facilities, for temporary storage of incoming raw product, and for building space. These adjustments reduce costs below the levels given by less than 1 percent and do not materially affect the cost relationships indicated in this study.

IV. SYNTHESIS OF COSTS IN PLANTS PROCESSING SELECTED COMBINATIONS OF FROZEN VEGETABLES

The major cost advantages of multiple- as compared with single-product plant operations consist of sharing variable and fixed inputs among different products. The magnitude of these savings depends on the adaptability of inputs used in processing different products and on whether these products are processed simultaneously or in different and independent time periods. Before the empiric treatment of cost measurement in multiple-product plants, it is appropriate to review some of the limitations to such cost-reduction opportunities in diversified frozen vegetable plant operations.

1. Variable Inputs and Costs

The equipment units with which variable inputs cooperate in processing any specified product are often discretely divisible, and the fixed and variable inputs tend to combine in relatively, or absolutely, fixed proportions. Furthermore, the operating stages, or "processes," frequently are determined with regard to the individual product, and the variable input-output relationships tend to be unaffected by multiple- as compared with single-product processing. This means that variable inputs and costs frequently may be estimated independently for each of the products comprising a given product mix or that minor variations may be ignored. In the analyses that follow, for example, unit variable costs of equipment repair, power, fuel, and steam inputs in multiple-product plants average from 0.5 percent to 1 percent less than in specialized single-product plants. The effect on the results was not considered sufficient to warrant adjustment of the single-product plant cost estimates to reflect these small savings.

Some economies in the purchase of items such as packaging materials and additives are attributed to multiple-product operations in situations where this type of plant organization results in a larger total volume of annual output. Where different products are simultaneously processed, underutilization of direct labor inputs on some jobs may be partially remedied by adjusting job assignments so that some workers perform two or more different tasks. But apparent input and cost savings of this type--in either multiple- or single-product plants--often cannot be realized because a worker's presence

is required on a given job on a contingency rather than capacity basis. Or, when the situation permits assigning a single worker to more than one job, a substantial amount of transit and set-up time may be involved in changing from job to job. This often reduces worker capacity below that anticipated. When products maturing in different seasons are processed in a given plant, the longer period of plant operations during the year may contribute to a more stable and efficient labor force. On the other hand, many of the labor inputs in frozen vegetable processing involve relatively low skills, and so savings from reduced labor turnover may tend to be smaller than otherwise indicated. Quantitative measures of cost savings due to these circumstances are extremely difficult to make.

Some additional costs may be anticipated in shifting from one product to another in multiple-product plants. Such costs might range from the essentially insignificant expense of operating a permanently installed bypass around specialized equipment units to the more consequential, although still small, costs of temporary removal or substitution of certain equipment units. In either case, such additional cost generally would be small enough to be ignored in practical applications of empirical analysis, and this is the procedure followed in this study. Their omission would tend to offset, in part, the effects of the minor cost savings attributed above to multiple-product operations.

2. Fixed Inputs and Costs

Management

In the estimation of long-run or planning costs, management inputs (and costs) in a plant of given scale, like those of equipment and other fixed inputs, are fixed in amount. Consequently, important savings in costs of management are achieved by reducing underutilization of this input. In many agricultural operations, a major part of these savings can often be achieved by the successive processing of products maturing in different seasons and so spreading the fixed costs of management over a greater total volume of annual output.

Where alternative processing of the different vegetables is not possible because of conflicting harvest seasons or other reasons, economies in the use

of management inputs often may be achieved by the simultaneous processing of these products, with consequent increase in plant capacity. This is due primarily to the more effective use of the management inputs as scale of output increases.

Thus, unit costs of management are reduced chiefly through increasing total annual volume. This may be achieved by increasing capacity rates of output with a fixed number of operating hours, by operating a greater number of hours in plants of fixed capacity, or both. In many freezer locations, such economies may be accomplished in multiple-product plants.

Equipment

The syntheses of specialized single-product plant costs developed in Part III of this study clearly indicate that a large proportion of the equipment required in processing a given product is adaptable for use in processing two or more of the six vegetables considered. Thus, for the most part, identical equipment units are used in the preparation and packaging of lima beans and green peas. Also, many items of equipment required in the processing of broccoli, Brussels sprouts, snap beans, and spinach are of similar or identical type and design. Economies of multiple equipment use cannot, of course, be achieved if there is substantial overlap in the harvesting and processing seasons of the alternative products.

3. Framework of the Analysis

Among the six vegetables studied, the California operating seasons for broccoli and Brussels sprouts correspond exactly over a period of several months.1/ This precludes multiple use of several expensive equipment units required in processing both vegetables. To a lesser extent, the harvesting and processing seasons of broccoli and spinach also coincide. Under most circumstances, however, the amount of overlap in the processing of broccoli and spinach may be minimized or avoided completely by staggered planting dates. Where some degree of seasonal overlap is unavoidable, the problem

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1/ For a discussion of harvesting dates, refer to pages 2 to 4 of this report.

frequently may be met by processing broccoli and spinach on an alternative shift basis for a portion of the season. Also, where plants are segmented into several adaptable broccoli-spinach processing lines, these products may be run simultaneously on separate lines. Either procedure is applicable where there are periods of reduced harvest--and consequently some excess plant capacity--at the beginning and end of the broccoli and spinach seasons.

Additional constraints are imposed on individual firms as they may be affected by local conditions regarding raw product procurement, capital requirements, sales and revenue conditions, attitudes concerning risk and uncertainty, and numerous other factors. Reflecting these conditions and attitudes, processing equipment and facilities used for handling a specified mix of the vegetables in any given plant may be highly specialized for individual products or modified for joint or multiple use in handling several.

To specify processing costs completely in relation to the many possible combinations of products, output rates, annual operating hours, and types of plant organization is beyond the scope of this study. However, a wide range of alternatives in the organization and design of plants processing combinations of the vegetables considered may be represented within the framework of three general models: Model I--multiple-product plants with each preparation and packaging line specialized and independent; Model II--multiple-product plants with adaptable lines but processing each product over different and independent periods of time; and Model III--plants combining the features of Models I and II.

The remainder of Part IV is devoted to syntheses of costs with combinations of products processed by plants conforming to these models. The resulting cost relationships will be compared among plants operating within the framework of the above models and with specialized single-product plants.

Model I Plant Organization and Costs

With Model I, a plant is organized and equipped for the specialized processing of each of the vegetables comprising a given product mix. For example, a plant processing only broccoli and Brussels sprouts would have specialized and separate preparation and packaging lines for each, and so on for any combination of the six vegetables considered. This model applies

primarily in situations where two or more products mature during the same season or where the physical characteristics of the products require different and specialized types of equipment. It also provides a basis for comparing relative costs of processing selected combinations of frozen vegetables with different types of plant organization.

Synthesis of costs in plants organized as specified by this model follows the line of analysis applied to single-product plants in Part III. As variable inputs and costs are treated as independent among different products, the major task is to specify and spread the common costs of buildings, management, and other fixed costs over the total volume packed of any given combination of products considered.

The planning cost equations representing total annual costs of the various operating stages and cost components developed for single-product plants are applicable generally in estimating costs in plants organized according to Model I specifications. The variables representing capacity output rates, R, and season operating hours, H, in these equations must be clearly identified because their interpretation varies among different operating stages and cost categories, depending on the composition of any specified product mix. Consequently, the procedure in estimating total annual costs with Model I plants involves the manipulation of the variables in the planning equations developed in Part III and summarized in Table 21 so as to apply to different product mixes of the vegetables studied. To demonstrate the modifications of planning equations given in Table 21 for application to conditions of Model I plant operations, these equations are grouped in two components--variable costs per season and annual fixed costs.

Estimated Variable Costs in Model I Plants

Because variable inputs and costs are assumed independent among products, planning equations representing total variable costs per season may be obtained by aggregating coefficients of variable cost terms of the planning equations developed for each product in Part III and summarized in Table 21. Planning cost equations obtained by this procedure (see Table 23) provide the basis for estimating annual variable costs with Model I plants.1/ As

1/ With variable costs independent among products, these equations will also apply to plants operating under the conditions of Models II and III.

TABLE 23

Summary of Planning Cost Equations for Estimating Annual Variable Costs
in Multiple-Product Frozen Vegetable Plants
California, 1960

Products	Variables[a]												
	H	RH	$RH\bar{p}$	H_rR	H_iR	H_bR	P_1RH	P_2RH	P_3RH	R_aH_{ra}	R_aH_{ia}	R_cH_{rc}	R_cH_{ic}
	coefficients in dollars												
Lima beans	26.408	15.589	0.116	32.564	19.147	4.582	b/						
Green peas	26.552	16.911	0.218	32.564	19.147	4.582							
Brussels sprouts	20.327	15.529	0.116	35.168	20.334		0.169	0.104	0.074				
Broccoli	16.699	30.474		7.817	4.655					33.424	18.387	26.199	15.211
Snap beans	16.228	18.720		7.817	4.655	4.750				27.478	15.781	27.478	15.781
Spinach	14.861	17.888		7.817	4.655					30.160	17.738	24.725	14.259

a/ Variables are defined as follows:

H = total number of hours operated per season.

RH = total season volume in 1,000 pounds per hour, pack-out basis.

$RH\bar{p}$ = manual grade-out percentage ($\bar{p}$) multiplied by total season volume.

H_rR = total season volume packed in retail cartons of lima beans, green peas, and Brussels sprouts. Volume cased per season in 24/10-ounce cases, all products.

H_iR = total season volume packed in institutional cartons of lima beans, green peas, and Brussels sprouts. Volume cased per season in 12/2½-pound cases, all products.

H_bR = total season volume packed in bulk bags or cases of lima beans, green peas, and snap beans.

P_1RH = total season volume of size No. 2 Brussels sprouts.

P_2RH = total season volume of size No. 3 Brussels sprouts.

P_3RH = total season volume of size No. 4 Brussels sprouts.

R_aH_{ra} = total season volume packed in retail cartons of broccoli spears, crosscut snap beans, and leaf spinach.

R_aH_{ia} = total season volume packed in institutional cartons of broccoli spears, crosscut snap beans, and leaf spinach.

R_cH_{rc} = total season volume packed in retail cartons of chopped broccoli, sliced snap beans, and chopped spinach.

R_cH_{ic} = total season volume packed in institutional cartons of chopped broccoli, sliced snap beans, and chopped spinach.

b/ Blanks indicate does not apply.

Source: Table 21.

noted earlier, these equations are not adjusted to reflect slightly reduced variable costs of equipment repair, power, fuel, and steam inputs that should result with multiple-product operations.

Estimated Annual Fixed Costs in Model I Plants

The modifications necessary in applying the planning equations representing annual fixed costs in single-product plants (Table 21) to conditions of Model I vary according to the specific operating stages or cost components and product mix considered. The modifications involved are presented below for pertinent stage and other cost classifications.

Preparation and Packaging.--The equipment used in preparation and packaging operations is, by Model I specifications, specialized for each vegetable processed. Planning equations representing annual fixed costs for a plant processing any given product mix are obtained by combining the separate equations for each product. With a two-product plant, for example, the planning equation for estimating total annual fixed costs for these operations is of the form: $TFC_1 + TFC_2 = (A_1 + B_1R_1) + (A_2 + B_2R_2)$, where TFC_1 and TFC_2 are total annual fixed costs of the preparation and packaging stages for products 1 and 2, R_1 and R_2 are plant capacity for the two products in 1,000 pounds per hour, and A and B are coefficients.

Fork-Truck Transportation.--The transportation equipment in this stage may be shared most effectively among products that are processed in different time periods. When products in any given mix are run during different periods of the year, the number of equipment units required in this operating stage in a given plant is determined by the product with the largest requirements. The planning equation representing total annual fixed costs for this stage in nonsimultaneous operations is of the form: $TFC = A + BR_{(max)}$, where $R_{(max)}$ relates to the capacity output rate of the product having the greatest fork-truck transportation requirements.

When products are processed simultaneously, the equipment cannot be shared effectively for most output rates, and the planning equation for a given product mix is obtained by combining the separate equations for each product in essentially the same manner as described above for the preparation and packaging operations.1/

1/ Because of high unit capacity, some sharing of forklift equipment among different products may be possible over certain ranges in plant capacity.

Casing, Management, Administration, and Miscellaneous Equipment.--As shown in Section 1 of Part III, annual fixed costs of these inputs are related to scale of plant and are treated as independent of the type of vegetable considered.[1/] The input requirements and the corresponding annual fixed costs are determined by the maximum requirements in any particular processing period. When the vegetables in a given product mix are processed in different and independent time periods, the planning equations assume the general form: $TFC = A + BR_{(max)}$, where $R_{(max)}$ is the capacity output rate of the product for which plant capacity is greatest. When the different products of a given mix are processed both simultaneously and alternatively, the R term represents the sum of the simultaneous output rates or $R_{(max)}$, whichever is greater.

Buildings.--In the single-product analyses, building costs were expressed in relation to plant size as measured by capacity output rate. The planning equation for estimating annual fixed costs of buildings is therefore of the general form: $TFC = A + BR$. To use this general equation for estimating annual fixed costs of buildings in any given Model I plant, where independent plant facilities are provided for each product, the term R must represent the sum of the capacity output rates for all vegetables in a given product mix ($R_1 + R_2 + \ldots$), irrespective of whether they are processed alternatively or simultaneously.

Estimated Total Annual Costs in Model I Plants

Planning equations for use in estimating annual fixed costs of the above stages and cost components are summarized in Table 24. To use these generalized equations for estimating costs in plants organized according to Model I specifications, the critical maximum value of the variable R must be selected to apply to the product mix considered.

By selecting appropriate values for the variables, the planning equations in Tables 23 and 24 may be used to estimate total annual variable and fixed costs for any given plant that processes any given combination of the vegetables considered. Total annual costs for a plant packing any specified product mix are obtained by aggregating annual variable and fixed costs for

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1/ Pages 31 to 49.

TABLE 24

Summary of Planning Cost Equations for Estimating Annual Fixed Costs of Operating Stages and Cost Components in Model I Multiple-Product Frozen Vegetable Plants California, 1960

Cost components	Constant term	R[a]
	coefficients in dollars	
Preparation and packaging costs		
Lima beans	7,792	1,402
Green peas	7,521	1,399
Brussels sprouts	10,863	2,467
Broccoli	12,900	3,075
Snap beans	13,203	3,934
Spinach	12,930	2,849
Fork-truck transportation costs		
Lima beans	700	38
Green peas	700	38
Brussels sprouts	420	155
Broccoli	600	121
Snap beans	547	177
Spinach	700	38
Casing costs	480	67
Building costs[b]	2,897	351
Management costs	4,040	1,944
Administrative costs	3,580	1,100
Miscellaneous equipment and costs	857	75

a/ Plant capacity in 1,000 pounds per hour, pack-out basis. See text for application in Model I plants.

b/ Includes buildings, water piping, and electrical wiring.

Source: Table 21.

each set of conditions considered. Because of the large number of computations involved, the calculation of total annual costs for the various product mixes and operating conditions is tedious and time-consuming. The general nature of the computations may be illustrated by estimating total annual costs with a simple two-product plant. Similar, but more numerous, calculations are required when more products are included.

Consider a plant processing broccoli and spinach in alternative time periods and organized according to Model I conditions. Let the first step be the calculation of annual variable costs. Each of the planning equations representing annual variable costs in processing these products may be expressed solely in terms of rates of output, R, and hours operated per season, H, by specifying the proportions of total season volume packed in the various container styles and forms of output.

Assume the total season volume of broccoli is distributed among container and pack styles as follows: 60 percent in retail cartons of broccoli spears, 15 percent in retail cartons of chopped broccoli, 20 percent in institutional cartons of broccoli spears, and 5 percent in institutional cartons of the chopped variety. For the spinach operation, assume also that the total season volume is distributed as follows: 60 percent in retail cartons of leaf spinach, 15 percent in retail cartons of chopped spinach, 20 percent in institutional cartons of leaf spinach, and 5 percent in institutional pack in chopped form.

Application of these values to the <u>variable</u> cost planning equations given in Table 23 redefines the equations in terms of output rates and length of season for the conditions specified to:

$$\begin{aligned} TVC_B = {} & \$16.699H + \$30.474RH + \$7.817(0.75)RH + \\ & + \$4.655(0.25)RH + \$33.424(0.60)RH + \\ & + \$18.387(0.20)RH + \$26.199(0.15)RH + \\ & + \$15.211(0.05)RH\ , \end{aligned} \tag{51}$$

which becomes:

$$TVC_B = \$16.699H_B + \$66.314R_BH_B\ . \tag{52}$$

A similar procedure gives an expression for total annual variable costs of processing frozen spinach as:

$$TVC_S = \$14.861H_S + \$50.980R_SH_S\ . \tag{53}$$

The subscripts S and B refer to spinach and broccoli.

Under the conditions specified, equations (52) and (53) can be used to estimate total annual variable costs of packing broccoli and spinach for any given combination of output rates and hours operated per season. For example, assume that the plant has a capacity output rate of 10,000 pounds per hour for broccoli and 6,000 pounds per hour for spinach. With an operating season of 500 hours for broccoli and 200 hours for spinach, the total annual variable cost for the broccoli operation is $337,965 and for spinach, $64,148. Annual variable costs for the combined operation total $402,113.1/

The modifications necessary in adapting the general planning cost equations in Table 24 for use in estimating annual fixed costs in Model I plants were discussed in the preceding section. In this example, the procedure involves selecting the appropriate capacity output rate--the value of R--for each of the stages and cost components in a broccoli-spinach plant operating under the conditions specified. With the exception of the specialized preparation and packaging stages, the fixed inputs of all other stages are common to the two products. The planning cost equations representing annual fixed costs of the preparation and packaging operations for each product are independent and additive. In the planning equations of the remaining, or "common," stages and cost components--except building costs--the variable R must be adjusted so as to represent the capacity output rate of the product having the larger requirements, which in this example is broccoli. With building costs, the variable R is adjusted to equal the sum of the capacity output rates of broccoli and spinach.

Carrying through the calculations involved for a plant with capacity output rates of 6,000 and 10,000 pounds per hour of spinach and broccoli, respectively, gives the combined annual fixed costs for the stages and cost components of both products. The results are shown below along with the appropriate capacity output rates, R, used in the calculations. The value of the variable R used in these calculations is stated in 1,000-pound-per-hour units.

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1/ Total variable costs per season with conditions more closely approximating circumstances of individual interest may be calculated by specifying values for the variables other than those assumed.

1.	Preparation and packaging costs	
	Broccoli ($R_B = 10$): $TFC_B = \$12,900 + \$3,075(10) = \$43,650$	
	Spinach ($R_S = 6$): $TFC_S = \$12,930 + \$2,849(6) = \underline{30,024}$	
	Total	$ 73,674
2.	Fork-truck transportation costs ($R = R_B = 10$)	1,810
3.	Casing costs ($R = R_B = 10$)	1,150
4.	Building costs ($R = R_B + R_S = 16$)	8,513
5.	Management costs ($R = R_B = 10$)	23,480
6.	Administrative costs ($R = R_B = 10$)	14,580
7.	Miscellaneous equipment costs ($R = R_B = 10$)	1,607
	ANNUAL FIXED COSTS FOR PLANT	$124,814

With the conditions assumed in this example, the preceding calculations give annual variable costs for the combined plant operations of $402,113 and annual fixed costs of $124,814. Total annual costs are $526,927. Average total costs for the <u>combined output</u> are obtained by dividing total plant costs by the total annual volume, that is, $526,927 by 6.2 million pounds (1.2 million pounds of spinach and 5.0 million pounds of broccoli), or approximately 8.5 cents per pound. To estimate average unit costs for each vegetable separately, the annual fixed costs of all stages and components except preparation and packaging must be <u>allocated</u> between broccoli and spinach on an arbitrary basis. In this example, a total of $51,140, or slightly less than 10 percent of total annual cost, must be allocated between broccoli and spinach.

Model II Plant Organization and Costs

With this model, the organization of the operating stages and cost components of specialized single-product plants is modified to permit joint, or multiple, use of equipment units and other inputs <u>common</u> to two or more vegetables processed in alternative and independent time periods.

It is beyond the scope of this study to include the many combinations of the six vegetables considered for which some degree of adaptability may exist. Instead, only the more common product combinations observed in the plants studied are synthesized. This involves the following product mixes: (1) broccoli-spinach, (2) broccoli-snap beans, (3) broccoli-spinach-snap beans, and (4) lima beans-green peas.

The synthesis of equipment requirements and costs of the various stages and cost components for these product combinations and the development of planning cost equations follow the economic-engineering procedures outlined earlier.[1] Several specifications and simplifications designed to reduce the number of computations include:

1. Variable costs are treated as independent among products. Costs of power, fuel, and operational equipment repair are slightly less than with specialized operations, but these savings reduce total variable costs less than 1 percent. Variable cost estimates are not adjusted to reflect these small savings.

2. The procedure used in synthesizing any given Model II plant involves adapting a specialized single-product plant to handle two or more products at the same hourly output rate but in different and independent time periods. This means that there will be some excess capacity at certain stages in relation to a particular product but that the hourly output capability of a given plant, in terms of packed weight equivalent, will be the same for each of the different vegetables in a given product mix. Under these conditions, scale of plant with multiple products is measured in a single output dimension, and economies of product diversification may be determined by comparing unit planning costs for plants processing a specified product mix with unit planning costs for more specialized operations.

3. In any adaptable processing line, there will be some equipment that is specialized for each product and some that is common to two or more. The amounts and costs of common equipment units and other common inputs are determined by the product having the greatest requirements.

4. The equipment arrangement, layout, and organization of the adaptable plants considered here are a synthesis based on studies of actual plant operations and on recommendations of processors and equipment manufacturers. They do not represent actual conditions in any particular existing plant.

In the following analyses, initial attention is given to the synthesis of costs and derivation of planning cost equations for Model II plants processing each of the product combinations specified above. These planning cost equations are then compared with those of Model I and single-product

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1/ See pages 22 to 27.

plants to estimate potential cost savings that may be achieved with Model II plant organization.

Synthesis of Equipment Requirements and Costs in Model II Plants

Broccoli-Spinach Plants.--Design of an adaptable broccoli-spinach processing line requires critical study of the various equipment units with respect to their use in handling both products during alternative or independent time periods and their integration into a well-organized adaptable processing line.

The nature of the problem is illustrated in Figure 14. Part A of the figure shows the layout of equipment units in the preparation and packaging stages of a specialized broccoli line, modified to include the conveyor supply method of trimming.[1] Part B shows the layout of a specialized spinach line of the same capacity.

Comparison of the layouts in Figure 14 indicates that some equipment units used in the various operations are adaptable for use with both products, while other units are specialized for each. The equipment units of the dumping stage are of different types and designs and are specialized for each product. The broccoli trimming conveyors also may be used as spinach inspection belts. In this event, however, the length and width of the conveyors of this stage are determined by the requirements for broccoli, as this product has the greater requirements for a given capacity output rate. All equipment units comprising the wash and blanch stage are suitable for either product except the specialized spinach wilt-tank assembly, which is bypassed when running broccoli. In addition, blanching capacity in an adaptable broccoli-spinach line is determined by the requirements for broccoli. All equipment in the packaging stage is common to both broccoli and spinach except specialized chop-line equipment.

A layout of an adaptable broccoli-spinach line, set up for spinach processing, is shown in Figure 15. Specialized spinach equipment is shown by the heavy solid lines and is identified by Roman numerals. Equipment common to broccoli and spinach is shown by the light dashed lines identified by Arabic numerals.

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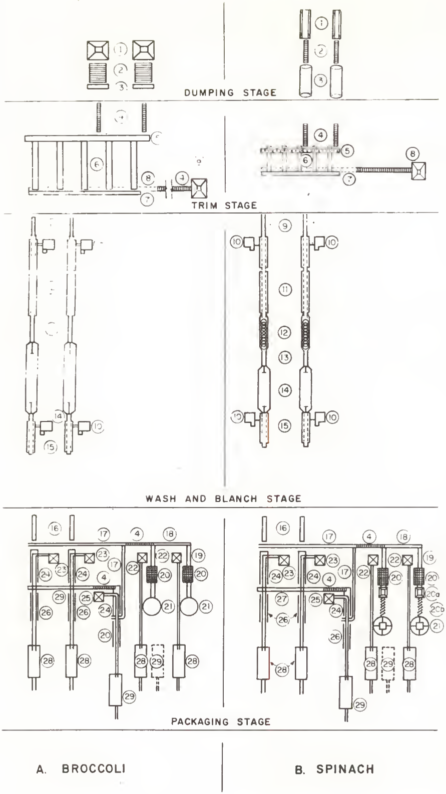
1/ For detailed cost comparisons between the conveyor supply method and the bin supply method of trimming broccoli, refer to pages 83 and 84.



LEGEND

A. Broccoli Processing Equipment

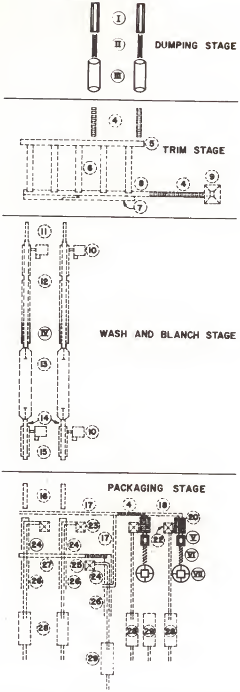
(1) Mechanical Bin Dumper (2)
(2) Slat-type Conveyor (2)
(3) Cross Collection Conveyors (2)
(4) Flight Conveyors (3)
(5) Trim Table Assembly; Bin Type (2)
(6) Waste Conveyor
(7) Waste Collection Hopper or Screen
(8) Washer Feed Conveyors (2)
(9) Water Pressure Booster Pumps (4)
(10) Flood-type Wash Assembly (2)
(11) Mesh Conveyors (2)
(12) Steam Blanch Assembly (2)
(13) Flood-type Cooling Assembly (2)
(14) Mesh Conveyors (2)
(15) Flume to Chop Lines
(16) Flight Conveyor
(17) Conveyor to Chop Line No. 2
(18) Feed Conveyors to Choppers (2)
(19) Retail and Institutional Carton Forming Assembly - Chop Lines (2)
(20) Retail Carton Forming Assembly - Spear Lines (2)
(21) Inspection and Packing Lines - Spears (3)
(22) Cross Conveyor to Institutional Hand-Pack Line
(23) Flight Conveyor
(24) Choppers (2)
(25) Retail and Institutional Carton Filling Machines - Chop Lines (2)
(26) Weigh Lines (3)
(27) Retail Carton Wrappers (4)
(28) Institutional Carton Wrappers (2)

B. Spinach Processing Equipment

(1) Dump Conveyor (2)
(2) Flight Conveyor (2)
(3) Dry-cleaning Reel (2)
(4) Flight Conveyor (4)
(5) Cross Distribution Conveyor
(6) Dry Inspection Belts (5)
(7) Cross Conveyor
(8) Waste Conveyor
(9) Washer-feed Conveyor (2)
(10) Water Pressure Booster Pump (4)
(11) Flood-type Washer (2)
(12) Wilt-tank Assembly (2)
(13) Blancher Feed Conveyor (2)
(14) Steam Blanch Assembly (2)
(15) Flood-type Cooling Assembly (2)
(16) Mesh Conveyor (2)
(17) Cross Conveyor to Chop Lines
(18) Conveyor to Chop Line No. 2
(19) Chopper Feed Conveyor (2)
(20) Choppers (2)
(20a) Chopper Discharge Hopper (2)
(20b) Feed Conveyor to Filler - Spiral-type (2)
(21) Retail and Institutional Carton Fillers - Chop Lines (2)
(22) Retail and Institutional Carton Forming Machines - Chop Lines (2)
(23) Retail Carton Forming Assembly - Leaf Line (2)
(24) Inspection and Packing Belts - Leaf Lines (3)
(25) Institutional Carton Forming Machines - Leaf Line (1)
(26) Weigh Belts - Leaf Lines (3)
(27) Cross Conveyor to Institutional Leaf Line
(28) Retail Carton Wrappers (4)
(29) Institutional Carton Wrappers (2)

Capacity: 5 to 6 tons each per hour; approximate scale: .025" = 1'

Figure 14. Layout of Specialized Frozen Broccoli and Spinach Lines, California, 1960.



SPECIALIZED SPINACH EQUIPMENT

- I Dump Conveyor (2)
- II Flight Conveyor (2)
- III Dry-Cleaning Reel (2)
- IV Wilt-tank Assembly (2)
- V Chopper Discharge Hopper (2)
- VI Feed Conveyor to Filler – Spiral Type (2)
- VII Retail and Institutional Carton Fillers – Chop Lines (2)

EQUIPMENT COMMON TO BROCCOLI AND SPINACH

- 4 Flight Conveyor
- 5 Cross Distribution Conveyor
- 6 Inspection Belts
- 7 Cross Conveyor
- 8 Waste Conveyor
- 9 Waste Collection Hopper or Garbage Screen
- 10 Water Pressure Boost Pump
- 11 Feed Conveyors
- 12 Flood Type Wash Assembly
- 13 Steam Blanch Assembly
- 14 Mesh Conveyor
- 15 Flood-type Cooling Assembly
- 16 Mesh Conveyor
- 17 Conveyor to Chop Lines
- 18 Conveyor to Chop Line No. 2
- 20 Choppers
- 22 Retail and Institutional Carton Forming Assembly – Chop Lines
- 23 Retail Carton Forming Assembly – Leaf Lines
- 24 Inspection and Packing Belts – Leaf Lines
- 25 Institutional Carton Forming Assembly – Leaf Line
- 26 Weigh Tables – Leaf Lines
- 27 Cross Conveyor to Institutional Leaf Line
- 28 Retail Carton Wrappers
- 29 Institutional Carton Wrappers

Heavy lines show specialized spinach equipment, while broken lines show equipment common to both spinach and broccoli. Capacity: 5 to 6 tons per hour; approximate scale: .025" = 1'.

Figure 15. Layout of an Adaptable Frozen Broccoli and Spinach Line Set up for Handling Spinach, California, 1960.

The figure shows that the amounts of common equipment in an adaptable processing line designed to achieve the same output rate for each product are based on the greater requirements necessary in broccoli operations. This results in some underutilization of inspection and blanching equipment when running spinach. When set up for a particular product, the equipment specialized for the other is removed from the line or is bypassed.

Specialized and common equipment requirements for the preparation and packaging operations of adaptable broccoli-spinach plants ranging in capacity from 2,000 to 20,000 pounds per hour are given in Table S-24 of the supplement. Equipment replacement costs and annual fixed charges corresponding to these requirements are given in Table 25.

The annual fixed charges corresponding to the equipment replacement costs in Table 25 are the basis of the generalized planning cost equations representing annual fixed costs of the preparation and packaging stages of adaptable broccoli-spinach plants summarized in the first two sections of Table 26. These cost equations are divided into several categories--those specialized for each product and those common to both; and within the packaging stage there is further subdivision in relation to form of pack-out and style of container. The planning cost equation representing annual fixed costs of other stages and cost components is the same as that developed for single-product plants, except for fork-truck transportation and building costs.[1/]

Planning cost equations for the specialized and common costs of the individual products may be read from Table 26 as follows:

$$TFC_{SBII} = (\$822 + \$271R)_B + (\$1,009 + \$292R)_S + + (\$24,903 + \$6,386R)_{SB}, \tag{54}$$

where

TFC_{SBII} = total annual fixed costs, in dollars, of processing broccoli and spinach with adaptable equipment.

$(\$822 + \$271R)_B$ = annual fixed costs of equipment specialized to broccoli.

- -

1/ Fork-truck transportation costs are based on the greater equipment requirements for broccoli, while the planning equation representing building costs has been increased 10 percent to reflect additional space requirements and costs for storage of specialized equipment and supplies when processing these products according to Model II specifications. For an analysis of these stages and components, refer to pages 31 to 49.

TABLE 25

Frozen Broccoli and Spinach Processing with Partially Adaptable Equipment: Replacement Costs and Annual Fixed Charges of Preparation and Packaging Equipment in Relation to Selected Rates of Output and Styles of Pack
California, 1960

Rates of output a/	PREPARATION — Specialized equipment — Replacement costs b/ — Broccoli			Spinach			Specialized equipment — Annual fixed charges c/ — Broccoli			Spinach			Common equipment — Replacement costs b/			Common equipment — Annual fixed charges c/		
	Equipment	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total
pounds per hour	dollars																	
2,000	3,025	1,268	4,293	8,325	710	9,035	499	317	816	1,374	178	1,552	26,663	1,460	28,123	4,399	365	4,764
4,000	3,097	1,303	4,400	8,325	710	9,035	511	326	837	1,374	178	1,552	31,864	2,270	34,134	5,258	568	5,826
6,000	3,200	1,352	4,552	8,325	710	9,035	528	338	866	1,374	178	1,552	38,173	3,020	41,193	6,299	755	7,054
8,000	6,194	2,602	8,796	16,650	1,339	17,989	1,022	651	1,673	2,747	335	3,082	61,410	4,538	65,948	10,133	1,135	11,268
10,000	6,297	2,651	8,948	16,650	1,339	17,989	1,039	663	1,702	2,747	335	3,082	66,403	5,289	71,692	10,956	1,322	12,278
12,000	6,400	2,700	9,100	16,650	1,339	17,989	1,056	675	1,731	2,747	335	3,082	72,788	6,026	78,814	12,010	1,507	13,517
14,000	6,452	2,725	9,177	16,650	1,339	17,989	1,065	681	1,746	2,747	335	3,082	77,620	6,655	84,275	12,807	1,664	14,471
16,000	9,497	4,001	13,498	24,975	2,409	27,384	1,567	1,000	2,567	4,121	602	4,723	93,616	8,309	101,925	15,447	2,077	17,524
18,000	9,600	4,050	13,650	24,975	2,409	27,384	1,584	1,013	2,597	4,121	602	4,723	97,910	9,048	106,958	16,155	2,262	18,417
20,000	9,652	4,075	13,727	24,975	2,409	27,374	1,593	1,019	2,612	4,121	602	4,723	103,844	9,674	113,518	17,134	2,419	19,553

Rates of output a/	PACKAGING — Common equipment — All forms and styles d/			Broccoli spears and leaf spinach — Retail style				Institutional style				Chopped broccoli and spinach, retail and institutional styles				Specialized equipment — Chopped broccoli			Chopped spinach		
	Equipment	Belting	Total	Purchase	Lease	Belting	Total	Purchase	Lease	Belting	Total	Purchase	Lease	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total
pounds per hour	Replacement costs b/ (dollars)																				
2,000	3,810	574	4,384	15,633	18,186	275	34,094	13,488	17,426	197	31,111	27,258	19,537	59	46,854	5,562	39	5,601	2,405	e/	2,405
4,000	4,522	574	5,096	16,033	18,186	305	34,524	13,488	17,426	197	31,111	27,258	19,537	59	46,854	5,562	39	5,601	2,405		2,405
6,000	5,641	598	6,239	16,833	18,186	433	35,452	13,988	17,426	296	31,610	27,258	19,537	59	46,854	6,602	39	6,641	4,098		4,098
8,000	7,549	896	8,445	32,066	36,372	576	68,438	15,146	17,426	344	32,916	45,074	39,074	118	84,266	11,124	79	11,203	4,810		4,810
10,000	8,617	897	9,514	32,666	36,372	675	69,713	15,546	17,426	418	33,390	45,074	39,074	118	84,266	11,124	79	11,203	6,503		6,503
12,000	9,768	936	10,704	33,666	36,372	797	70,835	15,746	17,426	492	33,664	45,074	39,074	118	84,266	13,204	79	13,283	6,503		6,503
14,000	11,235	985	12,220	34,666	36,372	940	71,978	27,776	34,852	590	63,218	54,516	39,074	118	93,708	15,224	79	15,303	8,196		8,196
16,000	12,598	1,298	13,896	49,599	54,558	1,060	105,217	29,905	34,852	640	65,397	73,203	58,611	177	131,991	16,686	118	16,804	8,908		8,908
18,000	13,769	1,348	15,117	50,499	54,558	1,161	106,218	30,105	34,852	689	65,646	73,203	58,611	177	131,991	19,806	118	19,924	8,908		8,908
20,000	14,888	1,373	16,261	51,099	54,558	1,274	106,931	30,505	34,852	787	66,144	73,203	58,611	177	131,991	20,786	118	20,904	12,294		12,294
	Annual fixed charges c/																				
2,000	629	144	773	2,579	1,819	69	4,467	2,226	1,743	49	4,018	4,498	1,954	15	6,467	918	10	928	397		397
4,000	746	144	890	2,645	1,819	76	4,540	2,226	1,743	49	4,018	4,498	1,954	15	6,467	918	10	928	397		397
6,000	931	150	1,081	2,777	1,819	108	4,704	2,292	1,743	74	4,109	4,498	1,954	15	6,467	1,089	10	1,099	676		676
8,000	1,246	224	1,470	5,291	3,637	144	9,072	2,499	1,743	86	4,328	7,437	3,907	30	11,374	1,835	20	1,855	794		794
10,000	1,422	224	1,646	5,390	3,637	169	9,196	2,565	1,743	105	4,413	7,437	3,907	30	11,374	1,835	20	1,855	1,073		1,073
12,000	1,612	234	1,846	5,555	3,637	199	9,391	2,598	1,743	123	4,464	7,437	3,907	30	11,374	2,179	20	2,199	1,073		1,073
14,000	1,854	246	2,100	5,720	3,637	235	9,592	4,583	3,495	148	8,216	8,995	3,907	30	12,932	2,512	20	2,532	1,352		1,352
16,000	2,079	325	2,404	8,184	5,456	265	13,905	4,934	3,485	160	8,579	12,078	5,861	44	17,983	2,753	30	2,783	1,470		1,470
18,000	2,272	337	2,609	8,332	5,456	290	14,078	4,967	3,485	172	8,624	12,078	5,861	44	17,983	3,268	30	3,298	1,470		1,470
20,000	2,457	343	2,800	8,431	5,456	319	14,206	5,033	3,485	197	8,715	12,078	5,861	44	17,983	3,430	30	3,460	2,029		2,029

a/ Pack-out basis.

b/ Derived from applying unit equipment costs to equipment requirements as given in Table S-24 of the supplement.

c/ Annual fixed charges of equipment calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent. Annual fixed charges of belting calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on investment, 3 percent.

d/ Includes scales, pans, and distribution belting common to entire packaging stage.

e/ Blanks indicate does not apply.

TABLE 26

Planning Cost Equations for Estimating Annual Fixed Costs of Processing Frozen Broccoli and Spinach with Partially Adaptable Equipment
California, 1960

Cost components	Constant term	R[a]
	coefficients in dollars	
Preparation stages		
Specialized equipment costs		
Broccoli	475	113
Spinach	896	202
Common equipment costs, both products	2,986	862
Total	4,357	1,177
Packaging stages		
Specialized equipment costs, retail and institutional styles		
Chopped broccoli	347	158
Chopped spinach	113	90
Total	460	248
Common equipment costs		
Retail leaf spinach and broccoli spears	2,540	615
Institutional leaf spinach and broccoli spears	2,360	328
Retail and institutional chopped broccoli and spinach	3,740	747
All styles, forms, and products	480	116
Total	9,120	1,806
Total preparation and packaging costs		
Specialized equipment		
Broccoli	822	271
Spinach	1,009	292
Total	1,831	563
Common equipment	12,106	2,668
Total	13,937	3,231
Fork-truck transportation costs[b]	600	121
Casing costs	480	67
Building costs[c]	3,187	386
Management costs	4,040	1,944
Administrative costs	3,640	1,123
Miscellaneous equipment and costs	850	77
TOTAL COMMON COSTS	24,903	6,386
TOTAL SPECIALIZED COSTS	1,831	563
TOTAL ANNUAL FIXED COSTS	26,734	6,949

a/ Plant capacity in 1,000 pounds per hour, pack-out basis.

b/ Based on fork-truck transportation requirements for broccoli processing.

c/ Building costs increased by 10 percent to allow for increased space requirements in adaptable broccoli-spinach plants.

Sources: Table S-24 of the supplement and Table 24 of the text.

$(\$1{,}009 + \$292R)_S$ = annual fixed costs of equipment specialized to spinach.

$(\$24{,}903 + \$6{,}386R)_{SB}$ = annual fixed costs of equipment, management, buildings, and other stages and cost components common to both products.

The variable cost planning equations given in Table 23 apply without modification to operations in adaptable broccoli-spinach plants. When expressed solely in terms of rates of output and hours operated per season, the variable cost planning equation is:1/

$$TVC_{SBII} = (\$16.699H + \$A_1RH)_B + (\$14.861H + \$A_2RH)_S \quad (55)$$

Total annual costs, including both variable and fixed costs, are obtained by combining equations (54) and (55). This gives:

$$\begin{aligned} TSC_{SBII} = {} & (\$822 + \$271R)_B + (\$1{,}009 + \$292R)_S + \\ & + (\$24{,}903 + \$6{,}386R)_{SB} + \qquad (56) \\ & + (\$16.699H + \$A_1RH)_B + (\$14.861H + \$A_2RH)_S . \end{aligned}$$

Broccoli-Snap Bean Plants.--A layout of an adaptable broccoli and snap bean line, set up for snap bean processing, is shown in Figure 16. Common use is made of inspection, washing, blanching, and cooling equipment in the preparation stages. In packaging crosscut beans, common use is made of carton-forming and closing equipment, weigh tables, scales and pans, wrappers, and several product distribution conveyors. All packaging equipment in the sliced line is common to both chopped broccoli and sliced beans. Specialized preparation equipment includes size graders, snippers, cutters, slicers, and auxiliary tie-in equipment. Specialized packaging equipment is required for filling retail, institutional, and bulk containers of crosscut beans.

Specialized and common preparation and packaging equipment requirements, in relation to selected output rates, container styles, and forms of pack,

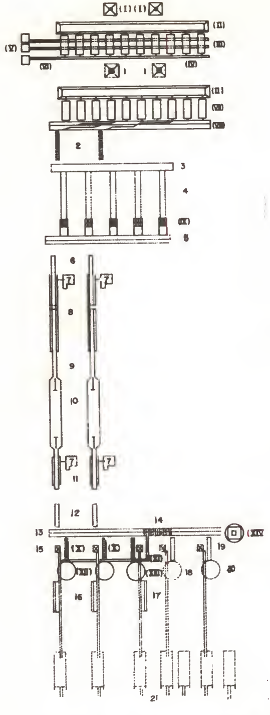
- -

1/ TVC_{SBII} = total annual variable costs, in dollars, of processing broccoli and spinach with adaptable equipment.

$(\$16.699H + \$A_1RH)_B$ = annual variable costs of processing broccoli.

$(\$14.861H + \$A_2RH)_S$ = annual variable costs of processing spinach.

A_1 and A_2 = constants whose values depend on those specified for the variables defined in Table 23.



LEGEND

SPECIALIZED SNAP BEAN EQUIPMENT

(I) Mechanical Bin Dumper
(II) Feed Hoppers
(III) Double Size Graders
(IV) Cross Collection Conveyors
(V) Flight Conveyors
(VI) Collection Bins, Sized Beans
(VII) Snipper Units
(VIII) Cross Collection Conveyors
(IX) Mechanical Cutters and/or Slicers
(X) Flight Conveyors
(XI) Cross Collection Conveyors
(XII) Retail Carton Fillers, Cuts
(XIII) Institutional Carton Fillers, Cuts
(XIV) Bulk Fill Assembly, Cuts

EQUIPMENT COMMON TO BROCCOLI AND SNAP BEANS

(1) Mechanical Bin Dumper
(2) Flight Conveyors
(3) Cross Distribution Conveyor
(4) Trimming and/or Inspection Conveyors
(5) Cross Collection Conveyors
(6) Feed Conveyors
(7) Water Pressure Booster Pumps
(8) Flood–Type Wash Assembly
(9) Feed Conveyors
(10) Steam Blanch Assembly
(11) Flood–Type Cooling Assembly
(12) Mesh Inspection Conveyors
(13) Cross Distribution Conveyors
(14) Flight Conveyors
(15) Carton Forming Equipment
(16) Retail Weigh Lines, Cuts/spears
(17) Institutional Weigh Lines, Cuts/spears
(18) Mechanical Fillers, Sliced or Chopped
(19) Slice Line Feed Belts
(20) Mechanical Filler, Sliced or Chopped
(21) Retail and Institutional Carton Wrapping Machines

Heavy lines show specialized snap bean equipment, while broken lines show equipment common to both broccoli and snap beans. Capacity: 5 to 6 tons per hour; approximate scale: .025" = 1'.

Figure 16. Layout of an Adaptable Frozen Broccoli and Snap Bean Line Set up for Handling Snap Beans, California, 1960.

are given in Tables S-25 and S-26 of the supplement. Replacement costs and annual fixed charges corresponding to these requirements are given in Table 27 and are the basis of the planning cost equations for the preparation and packaging operations that are summarized in Table 28. Planning cost equations for other stages and cost components, also given in Table 28, are the same as those developed for single-product plants, except for fork-truck transportation and building costs.[1/] Crew requirements, labor costs, and other variable costs for processing each product also were developed in the single-product analysis (Part III of this study) and apply without modification to the Model II plants considered here.[2/]

The aggregation of the planning cost equations into equations representing total annual costs for adaptable broccoli-snap bean plants follows the same procedures outlined earlier. If interest is only in the specialized and common costs for the individual products, irrespective of the form of output and style of container, the planning cost equation for total annual plant costs is:[3/]

$$\begin{aligned} TSC_{BSbII} = {} & (\$1{,}037 + \$271R)_B + (\$3{,}810 + \$1{,}654R)_{Sb} + \\ & + (\$25{,}970 + \$6{,}312R)_{BSb} + \\ & + (\$16.699H + \$A_1RH)_B + (\$16.228H + \$A_3RH)_{Sb}\,. \end{aligned} \tag{57}$$

- -

1/ Fork-truck transportation costs are based on the greater equipment requirements for snap bean processing, while building costs have been increased 10 percent to reflect additional space requirements and costs for storage of specialized equipment and supplies when processing broccoli and snap beans according to Model II specifications. For an analysis of general stages and cost components, refer to pages 31 to 49.

2/ For a summary of the planning cost equations representing annual variable costs, refer to Table 23.

3/ TSC_{BSbII} = total annual costs, in dollars, of processing broccoli and snap beans with adaptable equipment.

$(\$1{,}037 + \$271R)_B$ = annual fixed costs of equipment specialized to broccoli.

$(\$3{,}810 + \$1{,}654R)_{Sb}$ = annual fixed costs of equipment specialized to snap beans.

$(\$25{,}970 + \$6{,}312R)_{BSb}$ = annual fixed costs of equipment, management, buildings, and other stages and cost components that are common to both products.

$(\$16.699H + \$A_1RH)_B$ = annual variable costs of processing broccoli.

$(\$16.228H + \$A_3RH)_{Sb}$ = annual variable costs of processing snap beans.

A_1 and A_3 = constants whose values depend on those specified for the variables defined in Table 23.

TABLE 27

Frozen Broccoli and Snap Bean Processing with Partially Adaptable Equipment: Replacement Costs and Annual Fixed Charges of Preparation and Packaging Equipment in Relation to Selected Rates of Output and Styles of Pack
California, 1960

Rates of output a/	PREPARATION																	
	Specialized equipment												Common Equipment					
	Replacement costs b/						Annual fixed charges c/						Replacement costs b/			Annual fixed charges c/		
	Broccoli			Snap beans			Broccoli			Snap beans								
	Equipment	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total
pounds per hour	dollars																	
2,000	3,025	1,268	4,293	32,364	1,331	33,695	499	317	816	5,340	333	5,673	26,663	1,460	28,123	4,399	365	4,764
4,000	3,097	1,303	4,400	49,867	1,665	51,532	511	326	837	8,228	416	8,644	31,864	2,270	34,134	5,258	568	5,826
6,000	3,200	1,352	4,552	67,610	2,123	69,733	528	338	866	11,156	531	11,687	38,173	3,020	41,193	6,299	755	7,054
8,000	6,194	2,602	8,796	76,333	2,015	78,348	1,022	651	1,673	12,595	504	13,099	61,410	4,538	65,948	10,133	1,135	11,268
10,000	2,297	2,651	8,948	93,758	2,349	96,107	1,039	663	1,702	15,470	587	16,057	66,403	5,289	71,692	10,956	1,322	12,278
12,000	6,400	2,700	9,100	111,243	2,684	113,927	1,056	675	1,731	18,355	671	19,026	72,788	6,026	78,814	12,010	1,507	13,517
14,000	4,452	2,725	9,177	128,668	3,018	131,686	1,065	681	1,746	21,230	756	21,985	77,620	6,655	84,275	12,807	1,664	14,471
16,000	9,497	4,001	13,498	146,649	3,353	150,002	1,567	1,000	2,567	24,197	838	25,035	93,616	8,309	101,925	15,447	2,077	17,524
18,000	9,600	4,050	13,650	164,134	3,687	167,821	1,584	1,013	2,597	27,082	922	28,004	97,910	9,048	106,958	16,155	2,262	18,417
20,000	9,652	4,075	13,727	181,559	4,022	185,581	1,593	1,019	2,612	29,957	1,006	30,963	103,844	9,674	113,518	17,134	2,419	19,553

Rates of output a/	PACKAGING																		
	Replacement costs d/																		
	Common equipment												Specialized equipment						
	All forms and styles			Broccoli spears and cut snap beans						Chopped broccoli and sliced snap beans, retail and institutional styles			Snap beans				Broccoli		
				Retail style			Institutional style						Fillers			Flight conveyors			
	Equipment	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total	Equipment	Belting	Total	Retail	Institutional	Bulk		Equipment	Belting	Total
pounds per hour	dollars																		
2,000	3,810	574	4,384	31,925	138	32,063	29,429	59	29,488	49,338	98	49,436	3,784	3,784	4,278	1,667	6,007	276	6,283
4,000	4,522	574	5,096	32,125	167	32,292	29,429	59	29,488	49,338	98	49,436	3,784	3,784	4,278	1,667	6,207	345	6,552
6,000	5,641	598	6,239	32,525	226	32,751	29,620	89	29,709	50,378	98	50,476	4,541	3,784	4,278	1,667	6,807	551	7,358
8,000	7,549	896	8,445	64,250	335	64,585	29,720	103	29,823	89,234	197	89,431	7,568	3,784	4,278	2,501	11,220	654	11,874
10,000	8,617	897	9,514	64,550	379	64,929	29,870	125	29,995	89,234	197	89,431	7,568	3,784	4,278	2,501	11,720	810	12,530
12,000	9,768	936	10,704	65,050	453	65,503	30,020	148	30,168	91,314	197	91,511	9,082	7,568	8,386	2,501	12,320	1,033	13,353
14,000	11,235	985	12,220	65,550	526	66,076	59,240	177	59,417	102,776	197	102,973	12,380	7,568	8,386	3,334	14,114	1,274	15,388
16,000	12,598	1,298	13,896	97,125	613	97,738	59,340	192	59,532	139,443	295	139,738	12,129	7,568	8,386	5,001	18,377	1,326	19,703
18,000	13,769	1,348	15,117	97,575	679	98,254	59,440	207	59,647	142,563	295	142,858	13,623	7,568	8,386	5,001	18,927	1,515	20,442
20,000	14,888	1,373	16,261	97,875	723	98,598	59,640	236	59,876	143,543	295	143,838	16,921	7,568	8,386	5,001	19,427	1,688	21,115
	Annual fixed charges c/																		
2,000	629	144	773	4,086	35	4,121	3,722	15	3,737	6,871	25	6,896	624	624	713	298	991	69	1,060
4,000	746	144	890	4,117	42	4,159	3,722	15	3,737	6,871	25	6,896	624	624	713	298	1,024	86	1,110
6,000	931	150	1,081	4,185	57	4,242	3,755	22	3,777	7,043	25	7,068	749	624	713	298	1,123	138	1,261
8,000	1,246	224	1,470	8,237	84	8,321	3,772	26	3,798	12,183	44	12,232	1,249	624	713	448	1,851	164	2,015
10,000	1,422	224	1,646	8,286	95	8,381	3,793	31	3,827	12,183	44	12,232	1,249	624	713	448	1,934	203	2,137
12,000	1,612	234	1,846	8,369	113	8,482	3,821	37	3,858	12,527	44	12,576	1,499	1,249	1,426	448	2,033	258	2,291
14,000	1,854	246	2,100	8,451	132	8,583	7,509	44	7,553	14,418	44	14,467	2,043	1,249	1,426	597	2,329	319	2,648
16,000	2,079	325	2,404	12,480	153	12,633	7,526	48	7,574	19,198	74	19,272	2,001	1,249	1,426	895	3,032	332	3,364
18,000	2,272	337	2,609	12,554	170	12,724	7,542	52	7,594	19,713	74	19,787	2,248	1,249	1,426	895	3,123	379	3,502
20,000	2,457	343	2,800	12,603	181	12,784	7,575	59	7,634	19,875	74	19,949	2,792	1,249	1,426	895	3,205	422	3,627

a/ Pack-out basis.

b/ Derived from applying unit equipment costs to equipment requirements of specialized broccoli and snap bean operations and to equipment units common to both products. See Tables S-25 and S-26 of the supplement.

c/ Annual fixed charges of equipment calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent. Annual fixed charges of belting calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent; insurance, 1 percent; and interest on investment, 3 percent.

d/ Replacement costs of leased and purchased equipment are combined. Leased equipment is the Kliklok carton-forming and closing assembly.

TABLE 28

Planning Cost Equations for Estimating Annual Fixed Costs of Processing Frozen Broccoli and Snap Beans with Partially Adaptable Equipment
California, 1960

Cost components	Constant term	R[a]
	coefficients in dollars	
Preparation stages		
Specialized equipment costs		
Broccoli	467	114
Snap beans	2,700	1,393
Common equipment costs, both products	3,019	861
Total	6,177	2,368
Packaging stages		
Specialized equipment costs		
All styles and forms		
Broccoli	570	157
Snap beans	100	40
Retail cut snap beans	140	122
Institutional cut snap beans	400	46
Bulk cut snap beans	470	53
Total	1,680	418
Common equipment costs		
Retail broccoli spears and cut snap beans	2,410	548
Institutional broccoli spears and cut snap beans	2,210	282
Retail and institutional chopped broccoli and sliced snap beans	3,955	835
All styles, forms, and products	1,632	12
Total	10,207	1,677
Total preparation and packaging costs		
Specialized equipment		
Broccoli	1,037	271
Snap beans	3,810	1,654
Total	4,847	1,925
Common equipment	13,226	2,538
Total	18,073	4,463
Fork-truck transportation costs[b]	547	177
Casing costs	480	67
Building costs[c]	3,187	386
Management costs	4,040	1,944
Administrative costs	3,640	1,123
Miscellaneous equipment and costs	850	77
TOTAL COMMON COSTS	25,970	6,312
TOTAL SPECIALIZED COSTS	4,847	1,925
TOTAL ANNUAL FIXED COSTS	30,817	8,237

a/ Plant capacity in 1,000 pounds per hour, pack-out basis.

b/ Based on fork-truck transportation requirements for snap bean processing.

c/ Building costs increased by 10 percent to allow for increased space requirements in adaptable broccoli-snap bean plants.

<u>Broccoli-Spinach-Snap Bean Plants</u>.--The processing of frozen broccoli, spinach, and snap beans with Model II plant organization requires four different combinations of jointly used equipment. One combination is based on the fact that the equipment common to broccoli-spinach and broccoli-snap bean processing is common to all three vegetables. In addition, some equipment is common <u>only</u> to broccoli and spinach, some is common <u>only</u> to broccoli and snap beans, and some is common <u>only</u> to spinach and snap bean processing.

The syntheses of preparation and packaging equipment requirements and costs for broccoli-spinach and broccoli-snap bean combinations give all the data needed for the synthesis of adaptable broccoli-spinach-snap bean plants. Consequently, the calculation of costs in the adaptable three-product plant is accomplished by appropriate segregation of common and specialized equipment replacement costs and annual fixed charges synthesized in the preceding two-product analyses. Replacement costs and the corresponding annual fixed charges of specialized and common preparation and packaging equipment for adaptable broccoli-spinach-snap bean plants, developed in a manner similar to that applied in the preceding two-product models, are given in Table 29. Crew requirements, labor costs, and other variable costs for each of the three products are the same as those with the specialized single-product plants analyzed in Part III of this study.

Planning cost equations developed from the data in Table 29 are summarized in Table 30. These represent specialized and common cost-output relationships relating annual fixed costs to individual products, form of pack, and style of container. Considering only the specialized and common costs for the individual products, the planning cost equation representing total annual costs of processing broccoli, spinach, and snap beans in adaptable plants is:1/

$$\begin{aligned} TSC_{SBSbII} = {} & (\$1{,}590 + \$11R)_B + (\$1{,}120 + \$282R)_S + (\$3{,}820 + \$1{,}653R)_{Sb} + \\ & + (\$473 + \$182R)_{SB} + (\$410 + \$154R)_{BSb} + \\ & + (\$24{,}291 + \$6{,}261R)_{SBSb} + (\$16.699H + \$A_1RH)_B + \\ & + (\$14.861H + \$A_2RH)_S + (\$16.228H + \$A_3RH)_{Sb}. \end{aligned} \tag{58}$$

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1/ The first three parenthetical terms are annual fixed costs of equipment specialized to broccoli, spinach, and snap beans, respectively; $(\$473 + \$182R)_{SB}$ is annual fixed costs of equipment common to spinach and broccoli; $(\$410 + \$154R)_{BSb}$ is annual fixed costs of equipment common to broccoli and snap beans; $(\$24{,}291 + \$6{,}261R)_{SBSb}$ is annual fixed costs of equipment common to all three products; and the last three parenthetical terms are annual variable costs of processing broccoli, spinach, and snap beans, respectively.

TABLE 29

Frozen Broccoli, Spinach, and Snap Bean Processing with Partially Adaptable Equipment: **Replacement Costs and Annual Fixed Charges** of Preparation and Packaging Equipment in Relation to Selected Rates of Output and Styles of Pack
California, 1960

Rates of output[a/]	Replacement costs[b/]																
	Preparation				Packaging												
	Common equipment	Specialized equipment			Broccoli spears, leaf spinach, and cut snap beans						Chopped broccoli and spinach and sliced snap beans, retail and institutional styles				Bulk style	Distribution equipment	
					Retail style			Institutional style									
	Broccoli, spinach, and snap beans	Snap beans	Broccoli	Spinach	Broccoli, spinach, and snap beans	Broccoli and spinach	Snap beans	Broccoli, spinach, and snap beans	Broccoli and spinach	Snap beans	Broccoli, spinach, and snap beans	Broccoli and snap beans	Broccoli and spinach	Spinach	Snap beans	Broccoli, spinach, and snap beans	Snap beans
pounds per hour	dollars																
2,000	28,123	33,695	4,293	9,035	32,063	2,031	3,784	29,488	1,623	3,784	43,835	5,601	3,019	2,405	4,278	4,384	1,667
4,000	34,134	51,532	4,400	9,035	32,292	2,232	3,784	29,488	1,623	3,784	43,835	5,601	3,019	2,405	4,278	5,096	1,667
6,000	41,193	69,733	4,552	9,035	32,751	2,701	4,541	29,709	1,901	3,784	43,835	6,641	3,019	4,098	4,278	6,239	1,667
8,000	65,948	78,348	8,796	17,989	64,585	3,853	7,568	29,823	3,093	3,784	78,228	11,203	6,038	4,810	4,278	8,445	2,501
10,000	71,692	96,107	8,948	17,989	64,929	4,784	7,568	29,995	3,395	3,784	78,228	11,203	6,038	6,503	4,278	9,514	2,501
12,000	78,814	113,927	9,100	17,989	65,503	5,332	9,082	30,168	3,496	7,568	78,228	13,283	6,038	6,503	8,386	10,704	2,501
14,000	75,630	131,686	9,177	17,989	66,076	5,902	12,380	59,417	3,801	7,568	87,670	15,303	6,038	8,196	8,386	12,220	3,334
16,000	101,925	150,002	13,498	27,384	97,738	7,479	12,129	59,532	5,865	7,568	122,934	16,804	9,057	8,908	8,386	13,896	5,001
18,000	106,958	167,821	13,650	27,384	98,254	7,964	13,623	59,647	5,999	7,568	122,934	19,924	9,057	8,908	8,386	15,117	5,001
20,000	113,518	185,581	13,727	27,384	98,598	8,333	16,921	59,876	6,268	7,568	122,934	20,904	9,057	12,294	8,386	16,261	5,001
	Annual fixed charges[c/]																
2,000	4,764	5,673	816	1,552	4,121	335	624	3,737	268	624	5,968	928	498	397	713	773	298
4,000	5,826	8,644	837	1,552	4,159	368	624	3,737	268	624	5,968	928	498	397	713	890	298
6,000	7,054	11,687	866	1,552	4,242	446	749	3,777	314	624	5,968	1,099	498	676	713	1,081	298
8,000	11,268	13,099	1,673	3,082	8,321	636	1,249	3,798	510	624	10,388	1,855	996	794	713	1,470	448
10,000	12,278	16,057	1,702	3,082	8,321	789	1,249	3,827	560	624	10,388	1,855	996	1,073	713	1,646	448
12,000	13,517	19,026	1,731	3,082	8,482	880	1,499	3,858	577	1,249	10,388	2,199	996	1,073	1,426	1,846	448
14,000	14,471	21,985	1,746	3,082	8,583	974	2,043	7,553	627	1,249	11,936	2,532	996	1,352	1,426	2,100	597
16,000	17,524	25,035	2,567	4,723	12,633	1,234	2,001	7,574	968	1,249	16,489	2,783	1,494	1,470	1,426	2,404	895
18,000	18,417	28,004	2,597	4,723	12,724	1,314	2,248	7,594	990	1,249	16,489	3,298	1,494	1,470	1,426	2,609	895
20,000	19,553	30,963	2,612	4,723	12,784	1,375	2,792	7,634	1,034	1,249	16,489	3,460	1,494	2,029	1,426	2,800	895

a/ Pack-out basis.

b/ For aquipment requirements, specifications, and unit prices, see Part III, Section ?, of this study.

c/ Annual fixed charges of equipment calculated as 16.5 percent of equipment replacement cost, including depreciation, 10 percent; taxes, 1 percent; insurance, 1 percent; interest on investment, 3 percent (approximately 5.5 percent of the undepreciated balance); and fixed repairs and maintenance, 1.5 percent. Annual fixed charges of belting calculated as 25 percent of belting replacement cost, including depreciation, 20 percent; taxes, 1 percent, insurance, 1 percent; and interest on investment, 3 percent.

TABLE 30

Planning Cost Equations for Estimating Annual Fixed Costs of Processing Frozen Broccoli, Spinach, and Snap Beans with Partially Adaptable Equipment California, 1960

Cost components	Constant term	R[a]
	coefficients in dollars	
Preparation stages		
Specialized equipment costs		
Broccoli	1,590	11
Spinach	960	197
Snap beans	2,700	1,393
Common equipment costs, all products	3,010	861
Total	8,260	2,462
Packaging stages		
Specialized equipment costs		
Retail cut snap beans	140	122
Institutional cut snap beans	400	45
Bulk cut snap beans	470	53
Distribution equipment, snap beans	110	40
Retail and institutional, chopped spinach	160	85
Total	1,280	345
Common equipment costs		
Retail style		
Leaf spinach and broccoli spears	134	64
Leaf spinach, broccoli spears, and cut snap beans	2,400	548
Institutional style		
Broccoli spears and leaf spinach	92	47
Broccoli spears, leaf spinach, and cut snap beans	2,210	282
Retail and institutional styles		
Chopped broccoli and chopped spinach	247	71
Chopped broccoli and sliced snap beans	410	154
Chopped broccoli, sliced snap beans, and chopped spinach	3,447	680
All styles, forms, and products	480	116
Total	9,420	1,962
Total preparation and packaging costs		
Specialized equipment		
Broccoli	1,590	11
Spinach	1,120	282
Snap beans	3,820	1,653
Total	6,530	1,946
Common equipment		
Spinach and broccoli	473	182
Snap beans and broccoli	410	154
Broccoli, spinach, and snap beans	11,547	2,487
Total	12,430	2,823
Total	18,960	4,769
Fork-truck transportation costs[b]	547	177
Casing costs	480	67
Building costs[c]	3,187	386
Management costs	4,040	1,944
Administrative costs	3,640	1,123
Miscellaneous equipment and costs	850	77
TOTAL COMMON COSTS	25,174	6,597
TOTAL SPECIALIZED COSTS	6,530	1,946
TOTAL ANNUAL FIXED COSTS	31,704	8,543

a/ Plant capacity in 1,000 pounds per hour, pack-out basis.

b/ Based on fork-truck transportation requirements for snap bean processing.

c/ Building costs increased by 10 percent to allow for increased space requirements in adaptable broccoli-spinach-snap bean plants.

Lima Bean-Green Pea Plants.--As indicated in the single-product plant analyses of Part III, the equipment involved in the preparation and packaging stages of green pea and lima bean processing is identical except for minor differences in the initial cleaning and quality grading operations.1/ In green pea processing, a froth-cleaning assembly is substituted for the brine separation graders and temporary storage equipment used with lima beans and has no significant effect on the level of equipment costs for any given plant size. However, the various equipment units in the preparation stages have slightly greater capacities for handling green peas than for handling lima beans, and the amounts and costs of preparation equipment in an adaptable lima bean-green pea line are based on those applicable to lima beans (Table 10).

The planning equations for total annual fixed and variable costs in adaptable lima bean-green pea plants may be taken directly from Tables 23 and 24, respectively. This planning cost equation, reflecting slightly greater equipment requirements for lima bean processing, is:2/

$$TSC_{LbGpII} = (\$20{,}346 + \$4{,}977R)_{LbGp} + (\$26.408H + \$A_4RH)_{Lb} + \\ + (\$26.552H + \$A_5RH)_{Gp} . \quad (59)$$

Cost Comparisons and Potential Cost Savings in Model II Plants

The preceding analyses provide a synthesis of costs and the derivation of planning cost equations for processing frozen vegetables in: (1) specialized single-product plants; (2) Model I plants, that is, multiple-product

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1/ For a layout drawing of an adaptable green pea and lima bean line, refer to Figure 5. Additional details of the operations and costs of the various stages and cost components involved in processing these products are given in Part III of this study.

2/ TSC_{LbGpII} = total annual costs, in dollars, of processing lima beans and green peas with adaptable equipment.

$(\$20{,}346 + \$4{,}977R)_{LbGp}$ = annual fixed costs of equipment, management, buildings, and other stages and cost components common to both products.

$(\$26.408H + \$A_4RH)_{Lb}$ = annual variable costs of processing lima beans.

$(\$26.552H + \$A_5RH)_{Gp}$ = annual variable costs of processing green peas.

A_4 and A_5 = constants whose values depend on those specified for the variables defined in Table 23.

plants with each preparation and packaging line specialized and independent; and (3) Model II plants--multiple-product plants with adaptable lines but with products processed in different or alternative time periods. This section presents comparative costs with the three types of plants and illustrates, for specific operating conditions, some of the economies of Model II plant organization.

As variable costs are assumed independent among products, estimated cost savings with Model II, relative to single-product or Model I, plant organization may be calculated by comparing <u>total annual fixed costs</u> of the three types of plants considered. Cost comparisons for different types of plant organization are greatly facilitated by the specification of equal line capacities for processing each of the vegetables of a given product mix. This assumption permits previously developed planning cost equations for the different models to be used directly for calculating "savings equations" and provides one basis for quantitative and graphic demonstration of relative economies involved.[1/] Total annual fixed costs for single-product plants and Model I plants are compared with those of Model II plants processing the four product mixes discussed previously, that is, broccoli-spinach, broccoli-snap beans, broccoli-spinach-snap beans, and lima beans-green peas. Similar techniques and procedures are employed for each of the product mixes considered. The procedures and comparisons used are presented in relatively detailed form for plants processing broccoli and spinach, while comparisons and potential cost savings resulting from processing other product combinations in each of the three different types of plant organization are presented in more summary form.

<u>Broccoli-Spinach--Model II Versus Single-Product Plants</u>.--The total annual fixed cost of processing frozen broccoli and spinach in two single-product

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1/ To specify <u>different</u> line capacities for Model II plants would require that many more computations be made in synthesizing plant costs with the numerous combinations of rates that are possible. The procedure used reflects plant designs observed in most of the plants studied, and departure from the assumption of equal line capacities does not materially affect the general relationships demonstrated.

plants is simply the sum of the total annual fixed costs of each plant, that is:[1]

$$TFC_{(B+S)} = (\$25,354 + \$6,733R)_B + (\$25,484 + \$6,424R)_S . \quad (60)$$

A planning cost equation representing total annual fixed costs in Model II broccoli-spinach plants is given by the last entry in Table 26, that is:[2]

$$TFC_{SBII} = \$26,734 + \$6,949R . \quad (61)$$

The arithmetic difference, with equal output rates, between equations (60) and (61) provides one basis for estimating the cost savings that may be achieved by consolidating the operations in one plant as specified by Model II plant organization. A savings equation calculated in this manner is:[3]

$$TFC_{(B+S)} - TFC_{SBII} = TFC_{D_1} = \$24,104 + \$6,208R . \quad (62)$$

Equation (62) may be written in terms of average or unit savings per 1,000 pounds packed:[4]

$$ASC_{D_1} = \frac{\$24,104}{RH} + \frac{\$6,208}{H} . \quad (63)$$

<u>Broccoli-Spinach--Model II Versus Model I Plants</u>.--The reduction in total annual costs that may be achieved by processing frozen broccoli and spinach in Model II rather than in Model I plants may also be estimated by

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1/ The source of equation (60) is Table 21. It is assumed that the two specialized plants are independently owned and there are no joint costs of management or other overhead expense items. The parenthetical terms in the equation are annual fixed costs of processing broccoli and spinach, respectively.

2/ $R = R_S = R_B$.

3/ $TFC_{(B+S)}$ and TFC_{SBII} are as defined above, and TFC_{D_1} is total annual cost savings obtained by operating in Model II as opposed to specialized single-product plants.

4/ ASC_{D_1} is unit cost savings, in dollars, per 1,000 pounds packed; $R = R_S = R_B$; $H = H_S + H_B$; and RH is total season volume of broccoli and spinach.

comparing total annual fixed costs of plants operating under the conditions specified for these two models. It is again assumed that in a plant of given scale both products are processed at the same hourly output rate. The planning cost equation representing total annual fixed costs of Model I broccoli-spinach plants, developed from the data given in Table 24, is:

$$TFC_{SBI} = \$38,284 + \$9,933R . \tag{64}$$

A cost savings equation from processing broccoli and spinach in Model II rather than in Model I plants is obtained by comparing equations (61) and (64) and is:

$$TFC_{SBI} - TFC_{SBII} = TFC_{D_2} = \$11,550 + \$2,984R . \tag{65}$$

The difference in average costs per 1,000 pounds packed is obtained by dividing the total cost differences estimated by equation (65) by the total season volume of the two products. A planning cost equation calculated in this manner is:1/

$$ASC_{D_2} = \frac{\$11,550}{RH} + \frac{\$2,984}{H} . \tag{66}$$

Other Product Combinations.--The additional product mixes considered in this section are broccoli-snap beans, broccoli-spinach-snap beans, and lima beans-green peas.

Planning cost equations for total annual fixed costs of plants processing the above products, including the broccoli-spinach combination discussed above, are summarized in Table 31.2/ The table also shows savings equations representing the reduction in total annual costs that may be achieved by processing the specified product combinations in Model II rather than in single-product or Model I plants. For example, the savings in total costs attainable by processing broccoli and spinach in Model II as opposed to specialized single-product plants given by the first double-line entry of Table 31 is \$24,104 + \$6,208R. This is the same as equation (62) that was

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1/ ASC_{D_2} is unit cost savings, in dollars, per 1,000 pounds packed, obtained by processing broccoli and spinach in Model II rather than in Model I plants, and the other variables are as defined earlier.

2/ Planning cost equations given in Table 31 are based on the assumption of equal line capacities in plants processing each of the vegetables of a given product mix.

TABLE 31

Frozen Vegetable Plants: Comparison of Planning Cost Equations Representing Total Annual Fixed Costs of Single-Product, Model I, and Model II Plants Processing the Indicated Product Combinations with Equal and Constant Rates of Output California, 1960[a]

	Broccoli and spinach	Broccoli and snap beans	Broccoli, spinach, and snap beans	Lima beans and green peas
	1	2	3	4
	dollars			
Single-product vs. Model II plants				
Single-product[b]	50,838 + 13,157R	50,958 + 14,381R	76,442 + 20,805R	40,421 + 9,951R
Model II[c]	26,734 + 6,949R	30,817 + 8,237R	31,704 + 8,543R	20,346 + 4,977R
Cost savings[d]	24,104 + 6,208R	20,141 + 6,144R	44,738 + 12,262R	20,075 + 4,974R
Model I vs. Model II plants				
Model I[e]	38,284 + 9,933R	38,504 + 11,074R	51,434 + 13,923R	27,867 + 5,727R
Model II[b]	26,734 + 6,949R	30,817 + 8,237R	31,704 + 8,543R	20,346 + 4,977R
Cost savings[f]	11,550 + 2,984R	7,687 + 2,837R	19,730 + 5,380R	7,521 + 950R

a/ Assumes equal line capacities for processing each of the frozen vegetables specified.

b/ For a detailed analysis of costs with single-product plant organization, refer to Part III of this study.

c/ For a detailed analysis of costs with Model II plant organization, refer to Part IV of this study.

d/ Represents one measure of the reduction in total annual costs obtained by operating in Model II as opposed to single-product plants.

e/ For a detailed analysis of costs with Model I plant organization, refer to Part IV of this study.

f/ Represents one measure of the reduction in total annual costs obtained by operating in Model II as opposed to Model I plants.

developed in the more detailed analysis of the preceding section. Similarly, the reduction in total annual costs that may be achieved by processing broccoli and snap beans in Model II rather than in Model I plants is given by the last entry in column 2 of the table--that is, $7,687 + $2,837R--and so on, for any of the product combinations considered.

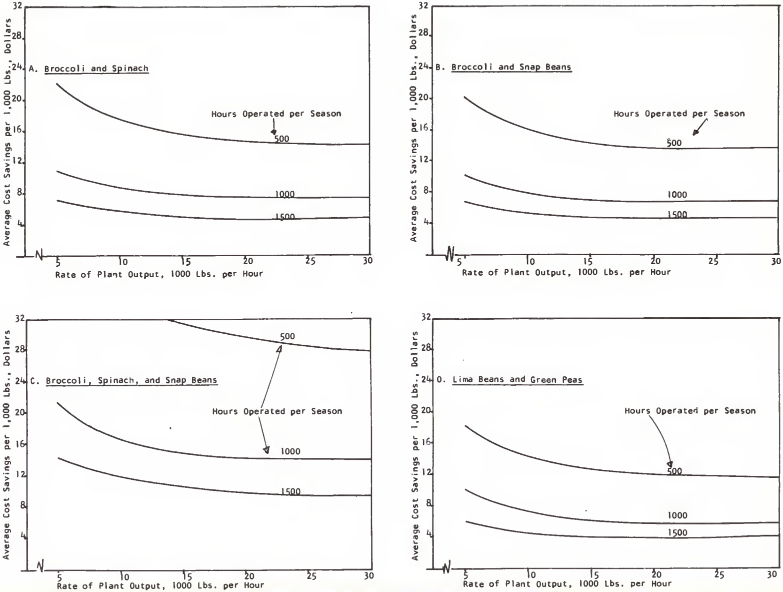
The Effect of Plant Size and Length of Season on Unit Cost Savings in Model II Plants

Planning equations representing average cost savings per 1,000 pounds packed are obtained by dividing the cost savings equations given in Table 31 by the total season volume of the products comprising a specified product mix and are graphically depicted in the different panels of Figure 17.

The figures show that for any given length of season the rate of reduction in unit cost savings is relatively small in plants above 15,000 pounds hourly output capacity. For example, panel A of Figure 17-A shows that the cost advantages of Model II broccoli-spinach plants are greatest in plants of relatively low capacity. With an operating season of 1,000 hours, the figure shows average unit cost savings for a plant of 5,000 pounds hourly capacity are about $11 per 1,000 pounds. These savings are approximately $9.00 per 1,000 pounds for a plant with 10,000 pounds hourly capacity and drop to about $7.50 with a plant capacity of 20,000 pounds per hour.

Panel A of Figure 17-A also demonstrates that cost differences in favor of Model II broccoli-spinach plants decrease as length of season, with a given capacity output rate, is increased. With output rate fixed at 5,000 pounds per hour, for example, unit cost savings are $22 per 1,000 pounds with an operating saeson of 500 hours. These savings drop to about $11 with an operating season of 1,000 hours and are about $7.00 per 1,000 pounds in a plant operating 1,500 hours per season.

Approximate numerical values of unit cost savings for the different plant models and product combinations considered, in relation to different output rates and lengths of season, can be read from the curves in Figure 17. Considering the relatively large number of relationships portrayed by these curves, however, the translation of the graphics into numerical terms is both tedious and time-consuming. Some of the specific values on which the curves in the figure are based are given in Table 32 to aid those interested in more detailed numerical comparisons.

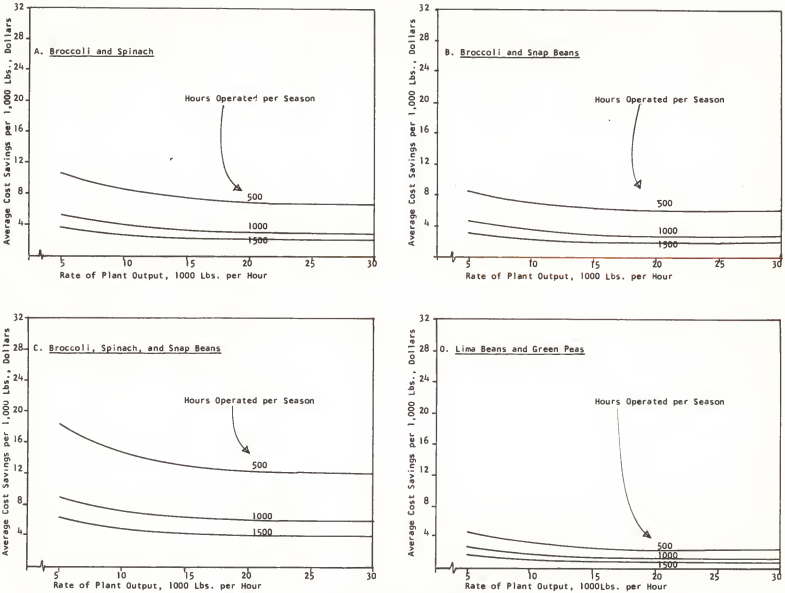


A. Model II Versus Specialized Single-Product Plants

Figure 17. The Effect of Rate of Plant Output and Length of Operating Season on Average Cost Savings per 1,000 Pounds Obtained by Processing Selected Frozen Vegetables in Different Types of Multiple-Product Plants, California, 1960.

(Continued on next page.)

Figure 17, continued.



B. Model II Versus Model I Plants

TABLE 32

Frozen Vegetable Plants: Estimated Unit Cost Savings with Model II Plant Organization in Relation to Selected Product Combinations, Plant Capacity, and Length of Season California, 1960

Plant types	Plant capacity: 5,000 pounds per hour	10,000 pounds per hour	20,000 pounds per hour
	dollars per thousand pounds		
Single-product vs. Model II plants			
Broccoli and spinach			
500 hours per season	22.06	17.24	14.83
1,000 hours per season	11.03	8.62	7.42
1,500 hours per season	7.35	5.75	4.94
Broccoli and snap beans			
500 hours per season	20.35	16.32	14.30
1,000 hours per season	10.17	8.15	7.15
1,500 hours per season	6.80	5.44	4.77
Broccoli, spinach, and snap beans			
500 hours per season	42.42	33.47	28.99
1,000 hours per season	21.21	16.73	14.50
1,500 hours per season	14.14	11.15	9.66
Lima beans and green peas			
500 hours per season	17.98	13.97	11.96
1,000 hours per season	8.99	6.98	5.97
1,500 hours per season	6.00	4.66	3.99
Model I vs. Model II plants			
Broccoli and spinach			
500 hours per season	10.59	8.28	7.13
1,000 hours per season	5.29	4.14	3.56
1,500 hours per season	3.53	2.76	2.38
Broccoli and snap beans			
500 hours per season	8.74	7.21	6.44
1,000 hours per season	4.38	3.61	3.22
1,500 hours per season	2.91	2.40	2.15
Broccoli, spinach, and snap beans			
500 hours per season	18.65	14.71	12.73
1,000 hours per season	9.33	7.35	6.37
1,500 hours per season	6.22	4.91	4.25
Lima beans and green peas			
500 hours per season	4.91	3.40	2.65
1,000 hours per season	2.45	1.70	1.37
1,500 hours per season	1.63	1.13	0.88

Important cost savings may be achieved by reducing the amount of underutilization of equipment, management, and other fixed and partially fixed inputs in seasonal operations. In many plant locations, these savings may best be achieved by processing a mix of products maturing in different seasons in plants conforming to Model II specifications and spreading the costs of common equipment and fixed inputs over a larger volume of annual output.

Model III Plant Organization and Costs 1/

In earlier sections of Part IV, conflicting seasons, physical characteristics of the different products, and the conditions and attitudes with which management operates were stressed as factors limiting the cost-reduction possibilities with joint or multiple use of fixed inputs for processing two or more vegetables in a single plant.

Among the six products considered, much of the equipment required for processing frozen broccoli, spinach, snap beans, Brussels sprouts, lima beans, and green peas is similar in type and design. This permits their joint or common use when processing these vegetables during alternative time periods. However, the harvest seasons of broccoli and Brussels sprouts coincide for relatively long periods, which makes it necessary to process these two products simultaneously. This precludes joint use of some common equipment units. Also, the preparation and packaging equipment units for processing frozen lima beans and green peas, although highly adaptable for each other, are not readily adaptable for use in processing the other four.

Among the vegetables considered, many product mixes may be processed with processing lines organized according to Model III specifications. For example, a plant processing frozen broccoli, spinach, and Brussels sprouts can be organized with one adaptable broccoli-spinach line conforming to Model II specifications and with one specialized Brussels sprouts line conforming to Model I organization. Similarly, a plant processing broccoli, spinach, green peas, lima beans, and Brussels sprouts can be organized into

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1/ Model III plants combine the operational features of Models I and II. Any specified Model III plant therefore is comprised of one or more lines specialized in the production of a single product and one or more lines adaptable for processing two or more products in different and independent time periods.

three basic lines: an adaptable broccoli-spinach line, an adaptable green pea-lima bean line (both organized according to Model II specifications), and a specialized Model I type line for processing frozen Brussels sprouts. Many other types of plants with operational features characteristic of Model III plant organization can be outlined. In this study, however, attention is limited to development of cost estimates for Model III plants processing a <u>six-product mix</u> of the vegetables previously considered. Other plant organizations and other product mixes could be considered in analyses patterned after the approach used here.

When consideration is given to plants processing a six-product mix of these vegetables, maximum adaptability under the conditions specified is achieved with a plant organized into three basic preparation and packaging lines. These involve one adaptable broccoli-spinach-snap bean line, one adaptable lima bean-green pea line, and one line specialized for processing Brussels sprouts. Two of these basic lines conform to Model II specifications, while the other is organized as specified by Model I. Such a plant combines Model I and Model II types of plant organization and therefore conforms to the definition of Model III plants.

Estimated Annual Fixed Costs in Model III Plants

Preparation and Packaging

The cost-output planning relationships developed in the earlier sections of Part IV may be extended without substantial modification to the estimation of costs with Model III plants. The procedure involves combining the planning equations previously developed for the preparation and packaging stages of Model II broccoli-spinach-snap bean and lima bean-green pea plants and of the specialized Brussels sprouts plants.

A planning equation representing annual fixed costs of a Model II broccoli-spinach-snap bean preparation and packaging line is obtained from the appropriate entry in Table 30. This equation, combining both specialized and common costs, is:[1]

$$TFC_{SBSbII} = (\$18,960 + \$4,769R)_{SBSbII} . \qquad (67)$$

1/ TFC_{SBSbII} is total annual fixed costs, in dollars, of preparation and packaging equipment in an adaptable broccoli-spinach-snap bean line, and R is individual capacity output rate of each product, in 1,000-pounds-per-hour packed weight equivalent, where line capacity is assumed equal for all three products.

Similarly, a planning equation for annual fixed costs of equipment required in the preparation and packaging stages of a Model II lima bean-green pea line may be read directly from Table 21.[1/] That is:

$$TFC_{LbGpII} = (\$7,792 + \$1,402R)_{LbGpII} \cdot \qquad (68)$$

Equipment requirements and specifications and the corresponding replacement costs and annual fixed charges of processing frozen Brussels sprouts with specialized preparation and packaging equipment were developed in detail in Part III.[2/] A planning cost equation representing annual fixed equipment costs for the preparation and packaging stages of frozen Brussels sprouts processing may also be read directly from Table 21. The planning equation so obtained is:

$$TFC_{BrSp} = (\$10,863 + \$2,467R)_{BrSp} \cdot \qquad (69)$$

A planning equation for estimating annual fixed equipment costs of the preparation and packaging stages of a Model III plant processing a six-product mix of frozen broccoli, spinach, snap beans, lima beans, green peas, and Brussels sprouts is obtained by combining planning equations (67), (68), and (69).

Other Operating Stages and Cost Components

In adapting the general planning equations given in Table 24 to Model III conditions, it is necessary to consider the output capacity rates of each of the three basic lines. Aside from the estimation of preparation and packaging costs developed above, the procedure is similar to that used in the development of annual fixed costs with Model I plants. For convenience, the modifications involved are presented for the specific stages and cost components given below.

Fork-Truck Transportation.--Fork-truck transportation requirements for an adaptable (Model II) broccoli-spinach-snap bean line are based on the greater equipment requirements and costs involved in snap bean processing. Consequently, when running either broccoli or spinach over this basic line

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1/ The appropriate planning equation to use in this case, however, is the one representing annual fixed equipment costs for lima bean processing, as this equation reflects the slightly greater equipment requirements and costs of preparing lima beans for freezing. For greater detail, refer to Part III of this study.

2/ Pages 70 to 81.

there will be some underutilization of fork-truck equipment. As broccoli and Brussels sprouts are run simultaneously, some of the fork-truck equipment that is underutilized for broccoli is available for handling Brussels sprouts. Net fork-truck requirements for the simultaneous processing of broccoli and Brussels sprouts are reduced accordingly. The resulting planning equation representing annual fixed costs for fork-truck equipment required for simultaneously processing broccoli and Brussels sprouts becomes:

$$TFC = \$942 + \$139(R_B + R_{BrSp}) . \tag{70}$$

As the input requirements and corresponding annual fixed costs of fork-truck transportation equipment are determined by the maximum requirements for any given processing period, equation (70) represents the estimating formula for the six-product mix considered here. As these requirements and costs are greater than in processing the remaining products, there will be a substantial underutilization of fork-truck transportation equipment when running the other four products in other, independent time periods. Some plants lease their peak fork-truck requirements to avoid such periods of excess capacity.

Casing, Management, Administration, and Miscellaneous Equipment.--The input requirements and corresponding annual fixed costs of these stages and cost components also are determined by the maximum requirements in any processing period of the year. When the different products of a given mix are processed, both simultaneously and alternatively, as in the six-product mix considered here, the R term of the general planning equations in Table 24 represents the sum of the simultaneous rates or the capacity output rate of the product for which line capacity is greatest--whichever is greater.[1/]

With the vegetables considered, input requirements and their annual fixed costs correspond to those required for the simultaneous processing of broccoli and Brussels sprouts. Therefore, the annual fixed cost planning equation for this segment of the Model III plant is obtained by summing the equations for casing, management, administrative, and miscellaneous equipment costs for Model I plants given in Table 24 and substituting for R in the

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1/ If the capacity output rate of a different product processed in an alternative and independent time period exceeds the sum of the output rates of the products that are simultaneously processed, it may be found economical to increase output rates of products alternatively processed in different seasons to approximately the same magnitude as those processed simultaneously; or expanding the product mix to include more commodities may be advisable.

resulting equation the sum of the simultaneous output rates for broccoli and Brussels sprouts. The resulting equation is:

$$TFC = \$8,957 + \$3,186(R_B + R_{BrSp}) \,. \tag{71}$$

Buildings.--To use the planning equation in Table 24 for estimating annual fixed costs of buildings in this example of Model III plant organization, the variable R must represent the sum of the capacity output rates for each of the processing lines involved. With one specialized and two adaptable lines for processing the six vegetables considered, the planning equation representing annual fixed building costs is:

$$TFC = \$2,897 + \$351(R_{SBSbII} + R_{LbGpII} + R_{BrSp}) \,. \tag{72}$$

Total annual fixed costs for all stages and cost components may now be combined into a single planning equation:

$$\begin{aligned} TFC_{III} = {} & (\$18,960 + \$4,769R)_{SBSbII} + (\$7,792 + \$1,402R)_{LbGpII} + \\ & + (\$10,863 + \$2,467R)_{BrSp} + \left[\$942 + \$139(R_B + R_{BrSp})\right] + \\ & + \left[\$8,957 + \$3,186(R_B + R_{BrSp})\right] + \\ & + \left[\$2,897 + \$351(R_{SBSbII} + R_{BrSp} + R_{LbGpII})\right] \,. \end{aligned} \tag{73}$$

Estimated Variable Costs in Model III Plants

As with the models discussed earlier, variable costs are independent among the different products, and the variable cost planning equations in Table 23 apply without modification in plants organized according to Model III specifications. By specifying values for the variables in the column headings in Table 23, the planning equation representing total variable costs per season for processing the six vegetables considered in a Model III plant organization may be written solely in terms of rates of output and hours operated per season, that is:1/

$$\begin{aligned} TVC_{III} = {} & (\$16.699H + \$A_1RH)_B + (\$14.861H + \$A_2RH)_S + \\ & + (\$16.228H + \$A_3RH)_{Sb} + (\$26.408H + \$A_4RH)_{Lb} + \\ & + (\$26.552 + \$A_5RH)_{Gp} + (\$20.327 + \$A_6RH)_{BrSp} \,. \end{aligned} \tag{74}$$

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1/ The parenthetical terms are total annual variable costs of processing broccoli, spinach, snap beans, lima beans, green peas, and Brussels sprouts, respectively, and the coefficients A_1, ..., A_6 are constants whose values depend on those specified for the variables defined in Table 23.

Estimated Total Annual Costs in Model III Plants

Total annual costs, including both fixed and variable components, for Model III plants operating as specified above are obtained by combining equations (73) and (74).

Cost Comparisons and Potential Cost Savings in Model III Plants

In this section, estimates are made involving cost comparisons and potential cost savings with six-product Model III plants relative to specialized single-product and Model I plants processing the same commodities. In developing these estimates, it is assumed that capacity output rates are equal for each of the processing lines. While this represents a special case, it permits relatively simple comparisons. Other comparisons not involving the assumption of equal line capacities can be made by following similar procedures.1/

Model III Versus Single-Product Plants.--The reduction in total annual cost achieved by processing spinach, broccoli, snap beans, Brussels sprouts, lima beans, and green peas in Model III rather than in specialized single-product plants can be estimated by comparing the planning equations of the two types of plant organization. Annual fixed costs are the basis of comparison. The total annual fixed cost of processing the specified six products in six single-product plants is the sum of the planning equations representing total annual fixed costs of each plant. This gives:2/

$$\begin{aligned} TFC_{(B+S+Sb+Gp+Lb+BrSp)} = {} & (\$25{,}354 + \$6{,}733R)_{B} + \\ & + (\$25{,}484 + \$6{,}424R)_{S} + \\ & + (\$25{,}604 + \$7{,}648R)_{Sb} + \\ & + (\$20{,}075 + \$4{,}974R)_{Gp} + \\ & + (\$20{,}346 + \$4{,}977R)_{Lb} + \\ & + (\$23{,}137 + \$6{,}159R)_{BrSp} \, . \end{aligned} \qquad (75)$$

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1/ Scale of output is considered only for the simple case of the single-plant, single-product firm and is based on plant costs only; raw product assembly costs are omitted. For additional discussion on this point, see pages 30 and 128.

2/ The source of the equation is Table 21. It is assumed that the six specialized plants are independently owned and there are no joint costs of management or other overhead expense items.

With the assumption of equal line capacities, equation (75) may be written:

$$TFC_{(B+S+Sb+Gp+Lb+BrSp)} = (\$140,000 + \$36,915R) . \qquad (76)$$

Also assuming equal line capacities, the terms in planning cost equation (73) are additive and may be written:

$$TFC_{III} = \$49,871 + \$15,341R . \qquad (77)$$

With the conditions specified, the arithmetic difference between planning equations (76) and (77) provides a basis for estimating the cost savings that may be achieved by consolidating the operations in one plant as specified by Model III organization. A planning equation calculated in this manner, representing total cost savings, is:1/

$$TFC_{D_9} = \$90,129 + \$21,574R . \qquad (78)$$

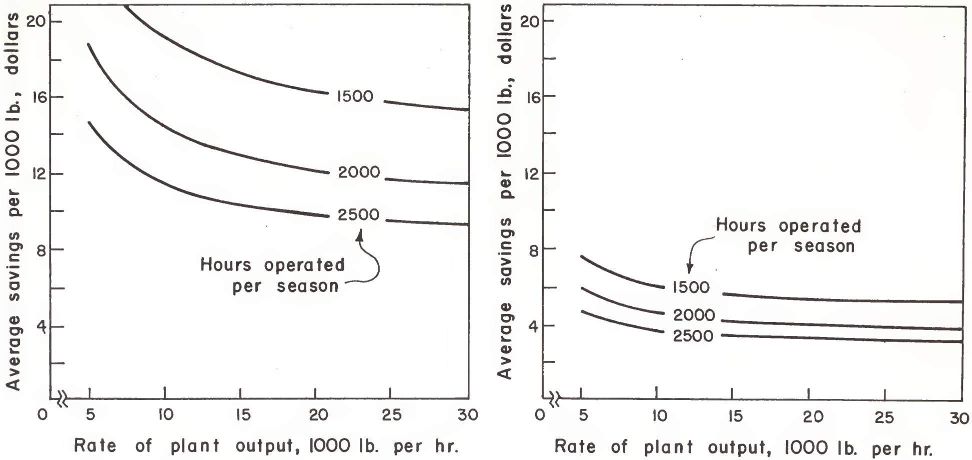
A planning equation representing average cost savings is:2/

$$ASC_{D_9} = \frac{\$90,129}{RH} + \frac{\$21,574}{H} . \qquad (79)$$

Equation (79) is graphically depicted in Figure 18-A. Unit savings achieved through operations in Model III rather than in single-product plants are substantial but drop quite rapidly as scale of plant and length of operation increases and annual fixed costs are spread over a greater volume of annual output. Beyond 20,000 pounds capacity output per hour, with a given number of operating hours, the unit cost savings level out, and their rate of reduction is relatively small in plants above that capacity. With an operating season of 2,000 hours, for example, average cost savings in a plant of 5,000-pounds-per-hour capacity in processing each product are about \$20 per 1,000 pounds. These cost savings drop to \$15 per 1,000 pounds in a plant with an output of 10,000 pounds per hour per line and are about \$12 with an hourly output of 30,000 pounds per line.

1/ TFC_{D_9} is one measure of the total annual cost savings obtained by operating in Model III as opposed to specialized single-product plants.

2/ ASC_{D_9} is unit cost savings, in dollars, per 1,000 pounds packed.



A. Model III Versus Specialized Single-Product Plants

B. Model III Versus Model I Plants

Figure 18. The Effect of Rate of Plant Output and Length of Operating Season on Average Cost Savings per 1,000 Pounds Obtained by Processing Frozen Vegetables in Different Types of Multiple-Product Plants, California, 1960.

Figure 18-A also shows that unit cost differences favoring Model III plants decrease as length of season, with a given plant capacity, is increased, and the differences are spread over a greater annual volume of output. With a plant capacity of 10,000 pounds per hour per line, unit cost savings per 1,000 pounds processed, with a 1,500-hour operating season, are about \$20. With a 2,000-hour operating period, these savings are about \$15 per 1,000 pounds and, with a season of 2,500 hours, are slightly over \$12 per 1,000 pounds packed.

Model III Versus Model I Plants.--Retaining the specifications of the preceding analysis, a planning equation for annual fixed costs of Model I plants processing the six vegetables considered, taken from Table 24, is:

$$TFC_I = \$78{,}083 + \$23{,}880R \,. \tag{80}$$

A cost savings equation calculated from equations (76) and (80), with equal and constant line capacities, is:1/

$$TFC_I - TFC_{III} = TFC_{D_{10}} = \$28{,}212 + \$8{,}539R \,. \tag{81}$$

In terms of unit cost savings per 1,000 pounds packed, equation (81) becomes:

$$ASC_{D_{10}} = \frac{\$28{,}212}{RH} + \frac{\$8{,}539}{H} \,. \tag{82}$$

Unit cost savings per 1,000 pounds packed, calculated from equation (82), are shown in Figure 18-B for selected lengths of season and for combined output rates ranging from 5,000 through 30,000 pounds per hour. The figure illustrates that the rate of reduction in unit cost savings is not substantial in plants above 15,000 pounds hourly output capacity. With an operating season fixed at 2,000 hours, average cost savings per 1,000 pounds processed are about \$7.00 with a plant capacity of 5,000 pounds per hour, slightly less than \$6.00 with an hourly capacity of 10,000 pounds, and about \$5.00 for a plant capacity of 30,000 pounds per hour.

Likewise, the rate of reduction in unit cost differences or savings per 1,000 pounds for any given plant capacity output rate between Model III and Model I plants is not rapid for any length of season considered. With an

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1/ $TFC_{D_{10}}$ is one measure of the total annual cost savings obtained by operating in Model III as opposed to the more specialized Model I plants.

hourly plant capacity of 10,000 pounds, for example, unit cost savings are about \$7.00 per 1,000 pounds packed in a 1,500-hour season, \$5.00 for a 2,000-hour season, and only \$4.00 in a 2,500-hour operating season.

As in other models, the level, shape, and spread of the unit cost differences or savings curves in Figure 18 clearly indicate that cost savings are much greater when the basis of comparison is between Model III and single-product plants.

V. SUMMARY AND CONCLUSIONS

The major objective of this study is the development of long-run or planning cost relationships for plants processing frozen broccoli, Brussels sprouts, snap beans, lima beans, spinach, and green peas. Planning cost equations relating total annual cost to plant capacity rates, length of operating season, style of container, form of pack, percentage of manual grade-out, and other variables are developed, first, for plants specialized in processing each product and, second, for plants processing combinations of the six vegetables.

1. Single-Product Plants

Estimation of the relative costs of alternative methods of operation is facilitated by combining closely related operations into different operating stages and cost components. Engineering and economic data for individual operations are used to estimate for each operating stage the quantities and costs of labor, equipment, and other inputs required in relation to selected rates of plant output, length of operating season, and other variables representing a wide range of operating conditions. Comparison of the stage cost estimates for different methods indicates the least-cost method and the aggregation of stage costs thus selected provide a basis for estimating total and average season planning costs for plants processing each product.

The study indicates that total unit costs of specialized single-product plants drop rapidly for any given length of season as size of plant, as measured by capacity output rate, is increased. Most of the advantages of increased size are largely exhausted, however, as plant capacity rate increases beyond 15,000 pounds per hour. The rates of reduction in unit planning costs

as size of plant increases are relatively uniform among the six vegetables studied. For example, with plants operating 500 hours per season and with a capacity output rate of 5,000 pounds per hour, the rate of reduction in unit planning costs per 1,000 pounds added capacity ranges from a low of \$2.56 per 1,000 pounds in specialized frozen spinach plants to a high of \$2.68 per 1,000 pounds in specialized frozen broccoli plants. With plants of 10,000 pounds hourly capacity--length of season remaining at 500 hours--unit cost reduction per 1,000 pounds added capacity ranges from 64 cents to 67 cents in frozen spinach and broccoli plants, respectively.1/

For any given capacity output rate among plants processing the commodities considered, substantial reductions in average cost are indicated as the length of operating season is increased. Economies associated with increased length of season, however, become relatively less important for seasons in excess of 750 hours. For example, with plants of 10,000 pounds hourly capacity and with a season of 250 hours, the rate of reduction in average planning costs ranges from a low of 11.2 cents per 1,000 pounds processed <u>per added hour</u> of operation per season for specialized green pea plants to a high of 16.30 cents in specialized frozen snap bean plants. When the operating season is increased to 1,000 hours--output capacity rate remaining the same--average cost reduction <u>per added hour</u> of operation per season ranges from 0.69 cent to 1.02 cents per 1,000 pounds processed in specialized frozen green pea and snap bean plants, respectively.

These results clearly indicate the dual nature of unit planning cost variation. First, with length of season specified, some fixed elements of cost in both variable and fixed inputs are spread over a greater season volume of output as plant capacity rate expands. Second, with any given plant capacity rate, the fixed costs of durable inputs are spread over an increasing volume as season volume is expanded through an increased number of operating hours. Unit planning costs therefore vary with both length of season and capacity output rates, and efficient plant organization calls for balancing the net cost effects of scale of plant output and operating

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1/ These results are based on specified values of the other variables of the individual planning equations (see Table 21), but use of values different than those assumed, although affecting the level of costs represented, does not materially affect the general relationships involved.

hours. The least-cost combination of rates and hours generally is achieved by operating the plant for the maximum time available during the season, consideration being given to restrictions on maximum daily operating times and cost rates.

The effect of variables other than length of operating season and plant capacity rate on total and average planning costs is also analyzed. For any specified plant capacity and length of season, total and unit costs increase substantially as the proportions of total season volume packed in retail cartons increase, and costs of processing any given vegetable rise rapidly as quality defects and the corresponding percentage of manual grade-out increase. To handle large fluctuations in the volume of daily receipts, as well as daily variations in the proportions of the vegetables which must be packed in various size containers, grades, and forms, considerable flexibility is provided in the plants synthesized in this study. For example, inclusion of space and facilities for temporary storage at the receiving stage and other points provides some insurance against hour-to-hour fluctuations in plant receipts. Also, large variations in the proportions packed in the various size containers and forms and grades of pack are allowed for by providing preparation, filling, and casing equipment capable of handling the total plant capacity output in any of the forms, grades, and styles appropriate for the product involved.

2. Multiple-Product Plants

Input-output relationships and costs developed for single-product plant operations are extended directly and in modified form as a basis for developing planning equations representing total and average costs in multiple-product frozen vegetable plants organized for processing various combinations of the six vegetables considered.

Complete specification of processing costs of the six vegetables in relation to the many possible combinations of products, output rates, annual operating hours, and types of plant organization is not attempted. However, a wide range of alternatives in the organization and design of plants processing combinations of the vegetables included is represented in the framework of three general models: Model I--multiple-product plants with each preparation and packaging line specialized and independent; Model II--multiple-product

plants with adaptable lines but operating over different and independent periods of time; and Model III--multiple-product plants combining the features of Models I and II.

With Model I plants, the synthesis of costs repeats the procedures used in the analysis of single-product plants. As variable inputs and costs are independent among different products, the major job involves identifying and spreading the common costs of buildings, management, administration, and other fixed cost components over the total volume of any given combination of vegetables packed. Planning cost equations representing total and average costs with Model I plant organization are summarized in Tables 23 and 24. Aside from representing a possible type of diversified plant organization, this model provides a basis for comparing relative costs of processing selected combinations of frozen vegetables with specialized rather than adaptable equipment and facilities.

With Model II plant organization, the layout and integration of equipment units in the preparation and packaging stages are modified to make joint or multiple use of those units common to two or more vegetables processed in alternative time periods. In line with this objective, input requirements and costs with adaptable processing lines are synthesized for the following product mixes: (1) broccoli-spinach, (2) broccoli-snap beans, (3) broccoli-spinach-snap beans, and (4) lima beans-green peas.

The reduction in total annual cost achieved by processing spinach and broccoli, for example, in adaptable (Model II) rather than specialized single-product plants is estimated by comparing the planning cost equations of the two types of plant organization. As variable costs are considered independent among products, the cost savings are calculated by comparing annual fixed costs of the single-product and adaptable plants only. The arithmetic difference, assuming equal output rates of the two products, between the planning cost equations representing annual fixed costs of single-product plants and broccoli-spinach plants organized according to Model II specifications provides the total cost savings (equation [51]) measured as follows: $TFC_{D_1} = \$24,104 + \$6,208R$, where TFC_{D_1} is total annual cost savings obtained by operating in Model II broccoli-spinach plants as opposed to specialized single-product plants, and R is plant capacity in 1,000 pounds per hour, assuming equal output rates for the two products. The equation is converted to an expression representing average or unit cost savings per 1,000 pounds output by dividing

it by total annual volume. The comparisons show that major cost savings are achieved by processing in adaptable (Model II) plants rather than in specialized plants, particularly for output rates below 15,000 pounds per hour and seasons up to 1,500 hours. For example, assume that a plant of 5,000 pounds hourly capacity operates 700 hours packing broccoli and 300 hours packing spinach. Average unit cost savings that may be achieved by processing these products in an adaptable (Model II) broccoli-spinach plant rather than in single-product plants amount to about $11 per 1,000 pounds. This represents a reduction in total annual processing costs (annual fixed costs plus annual variable costs) ranging from 12 to 15 percent, depending on the proportions packed among container and pack styles.1/ When plant capacity is doubled--length of season remaining the same--average unit cost savings drop to about $9.00 per 1,000 pounds but still represent a reduction of about 10 to 13 percent in total annual processing costs. Cost savings of the same approximate magnitude are evident when comparisons are made with length of season as a variable. To further extend the example, assume that the 5,000-pound-per-hour broccoli-spinach line were made adaptable to snap bean processing and that these were run an additional 300 hours. In this case, cost savings per 1,000 pounds would be about $16. This represents a reduction of between 17 and 21 percent in total annual processing of the three products as compared to the total costs of processing broccoli, spinach, and snap beans in single-product plants.

The reduction in costs that may be attained by processing frozen broccoli and spinach in Model II rather than in Model I multiple-product plants may also be estimated by essentially the same procedures. These savings, although substantial, are about 50 percent less than with single-product plant comparisons.

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1/ The actual percentage decrease in total annual processing costs depends on the distribution of total annual volume of the products packed among the different container and pack styles but will fall within the range specified. In this and following examples, the upper limit of the range indicates the percentage decrease in total annual costs, assuming the products are packed only in institutional cartons. The lower limit of the range shows the percentage decrease, assuming the products are packed only in retail cartons. The percentage decrease in total annual costs for various other combinations of container and pack styles will fall between the upper and lower limits of the range specified.

Cost comparisons for broccoli-snap bean, broccoli-spinach-snap bean, and lima bean-green pea plants organized according to Model II rather than Model I or single-product plant specifications indicate results of a similar nature. In general, the consolidation of operations with flexible Model II plant organization results in cost savings roughly proportional to the number of products included in the product mix.

The final analysis deals with Model III plant organization. In this analysis, consideration is given to plants processing a six-product mix of the vegetables studied, organized in a manner indicative of maximum adaptability. With the conditions and products specified, maximum adaptability is achieved with a plant organized into <u>three</u> basic preparation and packaging lines. Two of these basic lines conform to Model II specifications, while the other is organized as specified by Model I. There is <u>one</u> adaptable broccoli-spinach-snap bean line, <u>one</u> adaptable green pea-lima bean line, and <u>one</u> line specialized for processing Brussels sprouts. As with Models I and II, cost comparisons are made among the multiple-product models involved and with single-product plants to indicate the magnitude of cost savings that may be expected when the analysis is extended to include all six products included in the study. The comparisons indicate that unit cost savings are large when small plants operate in short seasons but become less important, although still significant, as scale of plant output and length of operating season increase and annual fixed costs are spread over a greater volume of output. With an operating season of 2,000 hours, for example, unit costs for a Model III plant of 5,000 pounds hourly capacity in processing <u>each</u> product are about $20 <u>less</u> per 1,000 pounds than when the six products are processed in independently-owned single-product plants. These cost savings drop to $15 per 1,000 pounds in a plant with 10,000 pounds hourly output per line and are about $12 with an hourly capacity of 30,000 pounds per line. Similar behavior of unit cost savings are evident when comparisons are made with length of season as a variable.

3. Concluding Remarks

Although many frozen vegetable plants in California have achieved a high level of efficiency, the selection of more economical operating techniques

and movement toward increased hours of operation and plants of higher capacity rates could lead to further cost reductions.

With any given scale of operation, the costs of management, equipment, and other fixed inputs must be paid regardless of their rate of utilization in any given production or accounting period. Consequently, important cost savings are achieved by reducing underutilization of these inputs in seasonal operations. In many agricultural operations, including the processing of the vegetables considered in this study, these savings can be best achieved by processing a mix of products maturing in different seasons and so spreading the costs of management and other fixed inputs over a greater annual volume of output. Where processing of a mix of different vegetables is not possible due to conflicting harvest seasons or other reasons, economies in the use of fixed inputs often can be achieved by the simultaneous processing of these products in situations where this alternative results in increased rates of plant output capacity. A complete evaluation of these potential cost savings requires consideration of the costs of assembly and distribution.

Recognized economic-engineering cost measurement techniques used in this study are particularly applicable in studies of multiple-product plant operations and costs as a means of isolating and studying the technical interrelationships among the different product processes and of permitting detailed consideration of problems of adaptability and flexibility within and among multiple-product processing lines. In addition, these procedures are well adapted for the segregation of common and specialized inputs and costs and minimize the effect of arbitrary allocations of joint costs to the various products, container styles, forms, and grades.

Finally, studies of multiple-product plant operations and costs deal with problems of great theoretical interest. At the practical level, they provide management with information useful in planning new facilities and in determining short-run adjustments of product mix. Results of these studies are useful to research workers in analyses of comparative advantage among producing regions and for researchers and others engaged in studies of rural area development. As multiple-product output is the dominant form of organization of the marketing firm, the past preoccupation in research with single-product studies may well expand to allow increased consideration of production and cost relationships of the multiple-product firm.

PART B. SUPPLEMENT

PART B. SUPPLEMENT--LABOR AND EQUIPMENT STANDARDS AND REQUIREMENTS FOR PREPARATION AND PACKAGING

This supplement presents many of the data used in developing the plant cost relationships given in Part A of this study.

The tables that follow include production standards and the corresponding crew and equipment requirements for the preparation and packaging stages of processing frozen broccoli, Brussels sprouts, green peas, lima beans, snap beans, and spinach. Crew and equipment requirements for these operating stages for each product and combination of products considered are given in relation to methods used, selected rates of output, styles of container, and forms and grades of output. The tables also specify the wage rates and unit equipment costs used in developing the cost data of Part A.

Data used in the estimation of labor performance standards were obtained from conventional time, production, and work sampling studies wherever these techniques were applicable to measure unit time required to perform a given operation. For jobs not adapted to measurement by time and production studies, plant operating and record data were used to establish labor production standards. These standards were then used to estimate the number of workers necessary to achieve any given rate and composition of output in relation to specific methods or production techniques used.

In developing labor performance standards for such use, the objective is to approximate "efficient" input-output levels. As defined in this study, the standards represent a level of job performance that can be achieved and regularly sustained by typical workers in work situations with minimum unavoidable delay. This involves estimating the net time expended in actual performance of the job as well as the minimum additional allowances for unproductive time such as rest periods, unavoidable production delays, and personal time.

An illustration of the procedure is provided by work sampling studies of the job of setting off and palletizing retail cases of frozen vegetables. These studies indicated an average net working time, including necessary miscellaneous operations, of 0.1093 man-minutes per case. With "allowances" amounting to 15 percent of the total working time, estimated gross unit time was 0.1286 man-minutes per case. This is equivalent to a standard production rate of 467 cases per hour.

Equipment requirements in plants of different line capacities and product organization were developed from production studies similar to the above, plant operating records, estimates based on engineering standards data, and specifications obtained from equipment manufacturers and contractors. When the engineering approach is used to estimate these requirements, the initial step is determination of the types and capacities of equipment in relation to production techniques used in an integrated operation. The objective is similar to that involved in the estimation of standard labor inputs discussed above. The standards would not reflect "theoretical" or "ideal" capacity rates but would include minimum allowances for unproductive time and generally would represent better-than-average, but not maximum, performance levels observed in actual plant operations. Like the labor performance standards discussed above, equipment standards developed by these procedures were then used to tabulate requirements representing the total number, capacities, and operating inputs of equipment units needed with different methods of operation and rates and forms of output.

References to specific tables in this supplement are given in appropriate sections of Part A of this study.

TABLE S-1

Frozen Vegetable Plants--Casing Stages: Crew Requirements for Casing Tray-Frozen Vegetables in Relation to Selected Rates of Output, Styles of Pack, and Methods Used
California, 1960

Rates of output a/	Retail style b/								Institutional style c/						
	Form case	Stitch case	Sten-cil case	Dump trays	Fill case	Guide car-tons	Seal and/or set off	Total	Form case	Stitch case	Sten-cil case	Dump trays	Fill case	Seal and/or set off	Total
pounds per hour	number of workers														
	Method A--Manual fill and seal														
2,000	1	1	--d/	1	1	e/	1	5	--	1	--	1	1	1	4
4,000	1	1	--	1	2		1	6	--	1	--	1	1	1	4
6,000	1	2	1	2	2		2	10	1	1	1	1	1	1	6
8,000	1	2	1	2	3		2	11	1	1	1	1	2	1	7
10,000	2	2	1	2	4		3	14	1	1	1	2	2	2	9
12,000	2	3	2	3	4		3	17	1	2	1	2	2	2	10
14,000	2	3	2	3	5		4	19	1	2	1	2	3	2	11
16,000	2	4	2	4	6		4	22	2	2	1	2	3	2	12
18,000	3	4	2	4	6		4	23	2	2	1	3	3	3	14
20,000	3	4	2	4	7		5	25	2	2	1	3	4	3	15
25,000	4	5	3	5	8		6	31	2	3	2	3	5	3	18
30,000	4	6	3	6	10		7	36	3	3	2	4	5	4	21
	Method B--Manual fill, machine seal														
2,000	1			1	1		1	4	1			1	1	1	4
4,000	1			1	2		1	5	1			1	1	1	4
6,000	1			2	2		1	6	1			1	1	1	4
8,000	1			2	3		2	8	1			1	2	1	5
10,000	2			2	4		2	10	1			2	2	1	6
12,000	2			3	4		2	11	1			2	2	1	6
14,000	2			3	5		2	12	1			2	3	2	8
16,000	2			4	6		3	15	2			2	3	2	9
18,000	3			4	6		3	16	2			3	3	2	10
20,000	3			4	7		3	17	2			3	4	2	11
25,000	4			5	8		4	21	2			3	5	2	12
30,000	4			6	10		5	25	3			4	5	3	15
	Method C--Machine fill and seal														
2,000	1			1	1	1	1	5	1			1	1	1	4
4,000	1			1	1	1	1	5	1			1	1	1	4
6,000	1			2	1	1	1	6	1			1	1	1	4
8,000	1			2	1	1	2	7	1			1	2	1	5
10,000	2			2	2	2	2	10	1			2	2	1	6
12,000	2			3	2	2	2	11	1			2	2	1	6
14,000	2			3	2	2	2	11	1			2	3	2	8
16,000	2			4	2	2	3	13	2			2	3	2	9
18,000	3			4	3	3	3	16	2			3	3	2	10
20,000	3			4	3	3	3	16	2			3	4	2	11
25,000	4			5	3	3	4	20	2			3	5	2	12
30,000	4			6	4	4	5	23	3			4	5	3	15
	Method D--Machine fill, manual seal														
2,000	1	1	--	1	1	1	1	6	--	1	--	1	1	1	4
4,000	1	1	--	1	1	1	1	6	--	1	--	1	1	1	4
6,000	1	2	1	2	1	1	2	10	1	1	1	1	1	1	6
8,000	1	2	1	2	1	1	2	10	1	1	1	1	2	1	7
10,000	2	2	1	2	2	2	3	14	1	1	1	2	2	2	9
12,000	2	3	2	3	2	2	3	17	1	2	1	2	2	2	10
14,000	2	3	2	3	2	2	4	18	1	2	1	[illegible]	3	2	11
16,000	2	4	2	4	2	2	4	20	2	2	1	[illegible]	3	2	12
18,000	3	4	2	4	3	3	4	23	2	2	1	3	3	3	14
20,000	3	4	2	4	3	3	5	24	2	2	1	3	4	3	15
25,000	4	5	3	5	3	3	6	29	2	3	2	3	5	3	18
30,000	4	6	3	6	4	4	7	34	3	3	2	4	5	4	21

a/ To convert pounds to 24/10-ounce cases, divide by 15; to convert pounds to 12/2½-pound cases, divide by 30.

b/ Labor production standards and wage rates--retail style: Form case (Methods A, B, C, and D)--549 cases per hour; hourly wage--$1.77. Stitch case (Methods A and D)--334 cases per hour; hourly wage--$1.77. Stencil case (Methods A and D)--79 cases per hour; hourly wage--$1.77. Dump trays (Methods A, B, C, and D)--334 cases per hour; hourly wage--$1.94. Manual fill (Methods A and B)--213 cases per hour; hourly wage--$1.77. Machine fill (Methods C and D)--576 cases per hour; hourly wage--$1.77. Guide cartons (Methods C and D)--476 cases per hour; hourly wage--$1.77. Manual seal and/or set off (Methods A and D)--300 cases per hour; hourly wage--$1.94. Machine seal and/or set off (Methods B and C)--467 cases per hour; hourly wage--$1.94.

c/ Labor production standards and wage rates--institutional style: Form case (Methods A, B, C, and D)--494 cases per hour; hourly wage--$1.77. Stitch case (Methods A and D)--334 cases per hour; hourly wage--$1.77. Stencil case (Methods A and D)--700 cases per hour; hourly wage--$1.77. Dump trays (Methods A, B, C, and D)--285 cases per hour; hourly wage--$1.94. Manual fill (Methods A and B)--200 cases per hour; hourly wage--$1.77. Manual seal and/or set off (Methods A and D)--290 cases per hour; hourly wage--$1.94. Machine seal and/or set off (Methods B and C)--450 cases per hour; hourly wage--$1.94.

d/ Dashes indicate job performed by case-forming or stitching crew.

e/ Blanks indicate does not apply.

TABLE S-2

Frozen Vegetable Plants--Casing Stages: Equipment Requirements for Casing Tray-Frozen Vegetables in Relation to Selected Rates of Output and Methods Used California, 1960[a]

Rates of output[b]	Case-in table[c]	Case-in machine[d]	Full-case conveyor[e]	Sealer-compressor[f]		Case stitcher[g]	Stencil equipment[h]	Glue stand[i]	Set-off conveyor[j]	Tally desk[k]
pounds per hour	feet	number	feet	number	type	number			feet	number
	Method A--Manual fill and seal									
2,000	4	[l]	14[j]			1	1	1		1
4,000	8		18[j]			1	1	1		1
6,000	8		18[j]			2	1	1		1
8,000	12		22[j]			2	1	1		1
10,000	16		26[j]			2	1	1		1
12,000	16		26[j]			3	2	1		1
14,000	20		30[j]			3	2	1		1
16,000	20		30[j]			4	2	2		1
18,000	24		44[j]			4	2	2		1
20,000	28		48[j]			4	2	2		1
25,000	32		52[j]			5	3	2		1
30,000	40		60[j]			6	3	2		1
	Method B--Manual fill, machine seal									
2,000	4		12[m]	1	C		1		10	1
4,000	8		16[m]	1	C		1		10	1
6,000	8		16[m]	1	C		1		10	1
8,000	12		20[m]	1	B		1		10	1
10,000	16		24[m]	1	B		1		10	1
12,000	16		24[m]	1	B		2		10	1
14,000	20		28[m]	1	A		2		10	1
16,000	20		28[m]	1	A		2		10	1
18,000	24		40[m]	1, 1	B, C		2		20	1
20,000	28		44[m]	2	B		2		20	1
25,000	32		48[m]	1, 1	A, B		3		20	1
30,000	40		56[m]	2	A		3		20	1
	Method C--Machine fill and seal									
2,000		1	7[n]	1	C		1		10	1
4,000		1	7[n]	1	C		1		10	1
6,000		1	7[n]	1	C		1		10	1
8,000		1	7[n]	1	B		1		10	1
10,000		2	24[n]	1	B		1		10	1
12,000		2	24[n]	1	B		2		10	1
14,000		2	24[n]	1	A		2		10	1
16,000		2	24[n]	1	A		2		10	1
18,000		3	31[n]	1, 1	B, C		2		20	1
20,000		3	31[n]	2	B		2		20	1
25,000		3	31[n]	1, 1	A, B		3		20	1
30,000		4	48[n]	2	A		3		20	1
	Method D--Machine fill, manual seal									
2,000		1	10[j]			1	1	1		1
4,000		1	10[j]			1	1	1		1
6,000		1	10[j]			2	1	1		1
8,000		1	10[j]			2	1	1		1
10,000		2	20[j]			2	1	2		1
12,000		2	20[j]			3	2	2		1
14,000		2	20[j]			3	2	2		1
16,000		2	20[j]			4	2	2		1
18,000		3	30[j]			4	2	3		1
20,000		3	30[j]			4	2	3		1
25,000		3	30[j]			5	3	3		1
30,000		4	40[j]			6	3	4		1

(Continued on next page.)

Table S-2, continued.

a/ Equipment requirements for both retail and institutional casing.

b/ To convert pounds to 24/10-ounce cases, divide by 15; to convert pounds to 12/2½-pound cases, divide by 30.

c/ Wood construction; 30-inch set-on surface for trays; 30-inch case-in surface inclined 25 degrees; 4 feet allowed for work place; plant or custom made; installed--$75 per 4-foot section.

d/ Pneumatic ram-lever type, 1/4-h.p. motor for retail cartons only; 576 24/10-ounce cases per hour capacity, with 15-percent allowance for wait and unavoidable delay. Includes tray dump conveyor assembly, 30" x 8', with 1/4-h.p. motor and drive; modified for use as case-in conveyor for institutional carton casing. Machine caser, installed--$2,695; tray dump conveyor, installed-$319.

e/ To sealer-compressor unit or to manual seal and set-off station.

f/ Top and bottom sealer and compressor unit, adjustable for different case dimensions. Type A--28-foot compressor; approximately 1,170 24/10-ounce cases (17,500 pounds) per hour capacity; installed--$6,460. Type B--20-foot compressor; approximately 810 24/10-ounce cases (12,150 pounds) per hour capacity; installed--$5,832. Type C--12-foot compressor; approximately 476 24/10-ounce cases (7,140 pounds) per hour capacity; installed--$4,998.

g/ Standard type; 12-inch throat; 334 cases per hour; $675.

h/ Includes stencil table, wheel, and pad. One set required for each 790 cases per hour; $60.

i/ Trough type, situated over set-off conveyor; installed--$25.

j/ Skate-wheel conveyor; 12" x indicated lengths; installed--$5.00 per foot.

k/ Desk surface; 22" x 60" x 1"; single drawer; $30.

l/ Blanks indicate does not apply.

m/ Includes one skate-wheel conveyor, 12" x length of case-in table, installed--$5.00 per foot; and one 12" x 8' belt conveyor with 1/2-h.p. motor for distributing cases to sealer, installed--$247 + $10.30L, where L is the length of conveyor frame in feet.

n/ Belt conveyor; 12" x indicated lengths; includes motor and drives with box turn and/or converger units; installed--$247 + $10.30L plus $480 for each box turn or converger. Conveyors modified for use when casing institutional cartons.

TABLE S-3

Frozen Vegetable Plants--In-Plant Transportation: Summary of Unit Time Requirements and Production Standards for Fork-Truck Operations
California, 1960

Fork-truck operations	Broccoli			Brussels sprouts			Snap beans			Other vegetables b/		
	Turn-around time	Transit time a/	Total	Turn-around time	Transit time a/	Total	Turn-around time	Transit time a/	Total	Turn-around time	Transit time a/	Total
	minutes per trip											
Receiving and preparation												
Unload full bins from truck and transport to temporary storage or dump	0.805	0.500	1.305	0.805	0.500	1.305	0.805	0.500	1.305	c/		
Load empty bins on truck from temporary storage	0.617	0.500	1.117	0.617	0.500	1.117	0.617	0.500	1.117			
Set on mechanical dumper, operate dump, and set off empty bins to temporary storage	1.610	1.000	2.610	1.610	1.000	2.610	1.422	0.750	2.172			
Set on pregraded bins of Brussels sprouts to mechanical dump and set off empty bins to storage				0.617	0.250	0.867						
Set on pregraded bins of snap beans to mechanical dump and set off empty bins to storage							1.422	1.000	2.422			
Miscellaneous d/	0.337	0.222	0.559	0.405	0.250	0.655	0.474	0.306	0.780	-- e/	--	0.250
Unavoidable delay f/	0.842	0.556	1.398	1.014	0.625	1.639	1.185	0.764	1.949	--	--	0.063
Total time requirements	4.211	2.778	6.989	5.068	3.125	8.193	5.925	3.820	9.745	--	--	0.313
Packaging and casing												
Transport full cases to cold storage from case-in crew	1.308	1.500	2.808	1.308	1.500	2.808	1.308	1.500	2.808	1.308	1.500	2.808
Miscellaneous g/	0.145	0.167	0.312	0.145	0.167	0.312	0.145	0.167	0.312	0.145	0.167	0.312
Unavoidable delay h/	0.363	0.417	0.780	0.363	0.417	0.780	0.363	0.417	0.780	0.363	0.417	0.780
Total time requirements	1.816	2.084	3.900	1.816	2.084	3.900	1.816	2.084	3.900	1.816	2.084	3.900
	minutes per thousand pounds											
Total time requirements i/	4.585	3.681	8.266	5.245	3.947	9.192	6.732	5.016	11.748	1.345	1.544	3.202
	pounds per man-machine hour											
Production standards			7,300			6,500			5,100			18,700

a/ Calculated by the equation: 0.005D, where D is distance traveled in feet.

b/ Includes lima beans, green peas, and spinach.

c/ Blanks indicate does not apply.

d/ Represents approximately 10 percent of total trucking time in receiving and preparation.

e/ Dashes indicate totals only shown.

f/ Represents approximately 20 percent of total trucking time in receiving and preparation.

g/ Represents approximately 10 percent of total trucking time in packaging and casing.

h/ Represents approximately 20 percent of total trucking time in packaging and casing.

i/ Minutes per trip converted to minutes per 1,000 pounds on the following basis: Net weight of full bins of broccoli and Brussels sprouts averages approximately 1,300 pounds each. Net weight of full bins of snap beans averages approximately 1,100 pounds each. Pallet loads of 24/10-ounce cases weigh approximately 1,350 pounds, assuming 90 cases comprise a pallet load. Pallet loads of 12/2½-pound cases weigh approximately 1,350 pounds, assuming 45 cases comprise a pallet load.

TABLE S-4

Frozen Lima Bean Plants--Preparation Stages: Crew Requirements in Relation to Selected Rates of Output California, 1960

Rates of output[a]	Equipment attendants[b]					Manual quality grading[c]
	Receiving	Brining and cleaning	Icing and distribution	Blanching	Boilers	
pounds per hour	number of workers					
5,000	1	3	1	1	1	$9.561 + 0.328\bar{p}$
10,000	1	3	2	1	1	$14.021 + 0.656\bar{p}$
15,000	1	6	2	2	2	$18.481 + 0.984\bar{p}$
20,000	1	6	3	2	2	$22.941 + 1.312\bar{p}$
25,000	2	7	4	3	3	$27.401 + 1.640\bar{p}$
30,000	2	9	4	3	3	$31.861 + 1.968\bar{p}$

a/ Pack-out basis.

b/ Labor production standards and wage rates: Receiving--20,000 pounds per hour; hourly wage--$1.94. Brining, cleaning, and blanching--10,000 pounds per hour; hourly wage--$2.28. Icing and distribution--7,500 pounds per hour; hourly wage--$1.94. Boiler attendants--10,000 pounds per hour; hourly wage--$2.86.

c/ Calculated from the equation for estimating sorter requirements: $N = 5.101 + 0.892R + 0.0656R\bar{p}$, where N is the number of sorters required, stated in whole numbers, R is plant capacity in 1,000 pounds per hour, and $\bar{p}$ is manual grade-out percentage.

TABLE S-5

Frozen Lima Bean Plants--Preparation Stages: Equipment Requirements in Relation to Selected Rates of Output
California, 1960

Rates of output a/	Receiving tanks b/		Conveyors c/	Shaker separators d/	Conveyors e/	Pneumatic separators f/		Flume assembly g/	Washers h/		Conveyors and flumes i/	Pumping assembly j/		Tubing k/	Dewater shakers l/	Briner platform m/	Quality graders n/		Pumping assembly j/		Flume assembly g/
pounds per hour	number	type	feet	number	feet	number	feet	feet	number	type	feet	number	type	feet	number	square feet	number	type	number	type	feet
5,000	1	B	10	1	8	1	A	3	1	A	10	o/					1	A	1	A	50
10,000	1	C	10	1	8	1	B	14	2	A	20	1	A	78	2	450	2	A			104
15,000	1 1	A B	20	2	16	1	D	27	2	C	28	1	B	78	2	450	2	C			120
20,000	1 1	A B	20	2	16	1	E	27	2 1	B C	35	2	A	134	3	574	2 1	B C			120
25,000	1 1	B C	20	3	16	2	C	28	1 2 1	A B C	45	1 1	A B	156	4	720	1 2 1	A B C			136
30,000	1 1	B C	30	3	24	2	D	28	4	C	45	1 1	A B	156	4	720	4	C			136

Rates of output a/	Temporary storage tanks p/		Walkways q/	Icing equipment r/		Flumes s/	Sorting tables t/	Flumes u/	Conveyors v/	Blanching equipment w/		Steam data: Boilers x/	Steam data: Steam	Steam data: Heating surface	Cooling flumes	Conveyors y/	Second quality graders n/		Bypass conveyors z/
pounds per hour	number	type	feet	number	type	feet	number	feet	feet	number	type	horsepower	pounds	square feet	feet	feet	number	type	width in inches
5,000	1 1	B C	35	1	A	45	1	17	10	1	A	20	690	108	50	10	1	A	12
10,000	2 1	A C	76	1	B	65	2	20	10	1	C	27	932	146	75	20	2	A	15
15,000	3 1	A C	98	1	B	93	3	26	20	2	B	50	1,725	270	100	20	2	C	15
20,000	4 1	A B	133	1	B	93	3	28	20	2	C	54	1,863	292	125	30	2 1	B C	15
25,000	4 2	A B	155	1	B	114	4	28	30	1 2	A C	74	2,453	400	125	40	1 2 1	A B C	18
30,000	4 2 1	A B C	155	1	B	135	5	36	30	3	C	81	2,794	437	150	40	4	C	18

(Continued on next page.)

Table S-5, continued.

a/ Pack-out basis.

b/ Mounted on shaker frame for continuous feed. Custom manufacture of three types: Type A--105 cubic feet; 1-h.p. motor; eccentric shaft; direct drive; installed--$705. Type B--240 cubic feet; 3-h.p. motor; eccentric shaft; direct drive; installed--$909. Type C--480 cubic feet; 4-h.p. motor; eccentric shaft; direct drive; installed--$1,259.

c/ For output rates below 15,000 pounds per hour, single conveyor with 3/4-h.p. motor and drive; installed--$383. For output rates from 15,000 to 30,000 pounds per hour, twin conveyors off single drive; 1-h.p. motor; installed--$553. For output rates above 30,000 pounds per hour, twin conveyors off single drive; 1-h.p. motor; and cross conveyor with 3/4-h.p. motor; total installed cost--$766.

d/ Custom-built trash separator; 12' x 3' with 3/4-h.p. motor and drive; 12,500-pounds-per-hour capacity; installed--$1,460.

e/ For output rates below 15,000 pounds per hour, single conveyor with 3/4-h.p. motor and drive; installed--$362. For output rates from 15,000 to 30,000 pounds per hour, twin conveyors off single drive; 1-h.p. motor; installed--$512. For output rates above 30,000 pounds per hour, twin conveyors off single drive; 1-h.p. motor; installed--$362; and cross conveyor 12" x 8' with 3/4-h.p. motor and drive to deliver beans to pneumatic separator; installed--$362.

f/ Type A--18-inch intake; 3 h.p.; 7,500-pounds-per-hour capacity; installed--$1,488. Type B--24-inch intake; 7½ h.p.; 10,000-pounds-per-hour capacity; installed--$2,698. Type C--30-inch intake; 7½ h.p.; 12,500-pounds-per-hour capacity; installed--$2,788. Type D--36-inch intake; 10 h.p.; 15,000-pounds-per-hour capacity; installed--$3,050. Type E--42-inch intake; 10 h.p.; 20,000-pounds-per-hour capacity; installed--$3,136.

g/ Includes flumes, dewater reels, waste water tubing, elbows, tees, adaptors, and other fittings.

h/ Flotation-type washers with destoner attachments. Type A--5,000-pounds-per-hour capacity; installed--$2,789. Type B--6,500-pounds-per-hour-capacity; installed--$3,089. Type C--7,500-pounds-per-hour capacity; installed--$3,389.

i/ Conveyor for output rates below 10,000 pounds per hour; 12" x 10'; installed--$383; flumes thereafter. Includes flumes, fittings, and waste or return water piping.

j/ Product pump assembly and intake tanks. Type A--3-inch intake; 12,000-pounds-per-hour capacity; installed--$695. Type B--4-inch intake; 18,000-pounds-per-hour capacity; installed--$900.

k/ Tube conveyors for product pumps--3-inch tubing of polyethylene and 4-inch tubing of aluminum. Includes elbows, tees, adaptors, valves, and recirculating equipment.

l/ 8,000-pounds-per-hour capacity; includes return water tank; installed--$670.

m/ Custom built; 5/16-inch safety plate; angle iron and black pipe construction; includes guard rails on stairway and platform. Platform is 10 feet above plant floor. Labor and materials cost, installed--$3.40 per square foot. Brine mix equipment, including tanks, brine density controller, and distribution piping; installed--$1,815. One brine station supplies four quality graders.

n/ Types and capacities same as for washers (see footnote h). Installed cost is $200 less than washers, since destoner equipment is not included.

o/ Blanks indicate does not apply.

p/ Storage capacity is eight hours at the output rates indicated. Tanks are galvanized iron, with sloped bottoms and sides. Type A--700 cubic feet; 26,000-pounds capacity; installed--$785. Type B--525 cubic feet; 19,500-pounds capacity; installed--$665. Type C--350 cubic feet; 13,000-pounds capacity; installed--$550.

q/ Installed over temporary storage tanks; 5/16-inch safety plate; 2 feet wide, with black pipe guard rails for stairs and walkways; installed--$1.50 per lineal foot.

r/ Type A--crusher with 3-h.p. motor; without blower; 40-cubic feet; galvanized iron tank mounted on warehouse truck; four scoop shovels; installed--$1,048. Type B--same as Type A but includes 10-h.p. blower and ice delivery tubing; installed--$2,052. Type C--same as Type A but includes additional tank assembly; installed--$1,257.

s/ Galvanized iron; 20 gauge; unseamed; installed--$7.00 per foot. Includes low-grade and high-grade product flumes for distribution to sorting tables and take-away flume at end of table.

t/ Includes 24" x 12½' neoprene belting, 24" x 12½' wire-mesh dewater belt (cascade), and 3/4-h.p. motor and drive. Tables equipped with drip pans. Installed costs: motor and drive--$280, each table; drip pans--$100 each; and belting estimated by the equation $0.41WL, where W is the width of belt in inches and L is the length of conveyor frame in feet.

u/ Galvanized iron; 20 gauge; unseamed; installed--$7.00 per foot.

v/ Mesh conveyor, dewater and distribution to blanchers; each conveyor 12" x 10'. For output rates below 15,000 pounds per hour, single conveyor, 3/4-h.p. motor and drive; installed--$432. For output rates from 15,000 to 25,000 pounds per hour, twin conveyors, 3/4-h.p. motor and drive; installed--$659. For output rates above 25,000 pounds per hour, three conveyors, 1-h.p. motor and drive; installed--$929.

w/ Requirements based on a 4-minute blanching time. Includes variable-speed motor and drive and blanch temperature-control assembly. Type A--12-foot cylinder, 6,400-pounds-per-hour capacity--$4,463, complete. Type B--15-foot cylinder, 8,000-pounds-per-hour capacity--$4,820, complete. Type C--18-foot cylinder, 10,000-pounds-per-hour capacity--$5,182, complete.

x/ Includes 125-pounds-per-square-inch Scotch marine dryback boiler, forced draft natural gas burner, feed-pump assembly, trim and fittings, and lagging and stack. Does not include steam piping and fittings to plant outlets. Installed costs of boiler units: 20 h.p.--$3,063; 27 h.p.--$3,344; 50 h.p.--$4,313; 54 h.p.--$4,313; 74 h.p.--$5,594; and 81 h.p.--$7,219.

y/ Mesh conveyor, dewater and distribution to quality graders; each conveyor 12" x 10'. For output rates below 10,000 pounds per hour, single conveyor, 3/4-h.p. motor and drive; installed--$432. For output rates from 10,000 to 20,000 pounds per hour, twin conveyors, 3/4-h.p. motor and drive; installed--$659. For output rates from 20,000 to 25,000 pounds per hour, three conveyors, 1-h.p. motor and drive; installed--$929. For output rates above 25,000 pounds per hour, two twin conveyors, each with 3/4-h.p. motor and drive; installed--$1,318.

z/ Wire-mesh conveyor to bypass second quality graders; indicated widths x 25'; 1-h.p. motor and drive; installed--$605.

TABLE S-6

Frozen Lima Bean and Green Pea Plants--Packaging Stages: Crew Requirements in Relation to Selected Rates of Output and Styles of Pack California, 1960

Rates of output a/	Retail style b/							
	Feed cartons	Attend fill	Check-weigh	Inspect cartons	Tray off	Supply skid and tally	Supply materials	Total crew
pounds per hour	number of workers							
5,000	c/	1	1	1	2	1	d/	6
10,000	1	1	2	2	4	1	1	12
15,000	1	2	3	3	5	2	1	17
20,000	2	2	4	4	7	2	2	23
25,000	2	3	4	5	8	3	2	27
30,000	2	3	5	5	10	3	3	31

Rates of output a/	Institutional style e/							
	Feed cartons	Attend fill	Check-weigh	Inspect cartons	Tray off	Supply skid and tally	Supply materials	Total crew
pounds per hour	number of workers							
5,000	c/	1	1	1	1	1	d/	5
10,000	1	1	2	2	2	1	1	10
15,000	1	2	3	3	3	2	1	15
20,000	2	2	4	4	4	2	2	20
25,000	2	3	4	5	4	3	2	23
30,000	2	3	5	5	5	3	3	26

Rates of output a/	Bulk style f/								
	Feed trays	Attend fill	Truck skids	Dump to cluster breaker	Operate fill and check-weigh	Set off bags or cases	Supply materials	Total crew	Attend distribution
pounds per hour	number of workers								
5,000	g/	1	2	1	2	1	1	8	1
10,000	1	1	2	2	4	2	1	13	1
15,000	1	1	2	2	6	2	1	15	1
20,000	2	2	2	3	6	3	1	19	1
25,000	2	2	4	3	8	3	2	24	1
30,000	3	3	4	4	10	4	2	30	1

a/ Converted to pounds per hour on the basis of 10-ounce retail cartons, 2½-pound institutional cartons, 50-pound bags or cases, and 20-pound trays.

b/ Labor production standards and wage rates--retail style: Feed cartons and attend fill--19,500 cartons (12,188 pounds) per hour; hourly wage--$1.77. Check-weigh and inspect cartons--9,750 cartons (6,094 pounds) per hour; hourly wage--$1.77. Tray off--5,130 cartons (3,206 pounds) per hour; hourly wage--$1.94. Supply skid and tally and supply materials--19,500 cartons (12,188 pounds) per hour; hourly wage--$1.94.

c/ Cartons fed by fill attendant at this output rate.

d/ Materials supplied by skid supply man at this output rate.

e/ Labor production standards and wage rates--institutional style: Feed cartons and attend fill--5,100 cartons (12,750 pounds) per hour; hourly wage--$1.77. Check-weigh and inspect cartons--2,500 cartons (6,375 pounds) per hour; hourly wage--$1.77. Tray off--2,550 cartons (6,375 pounds) per hour; hourly wage--$1.94. Supply skid and tally--8,000 cartons (20,000 pounds) per hour; hourly wage--$1.94. Supply materials--5,100 cartons (12,750 pounds) per hour; hourly wage--$1.94.

f/ Labor production standards and wage rates--bulk style: Hourly wage rates are the same for all jobs--$1.94. Feed trays for loose fill and attend tray fill--200 trays (4,000 pounds) per hour; Truck skids--200 trays (4,000 pounds) per hour. Dump to cluster breaker--150 trays (3,000 pounds) per hour. Operate bag or case fill and set off filled containers--150 bags or cases (7,500 pounds) per hour. Supply materials (including stenciling)--400 bags or cases (20,000 pounds) per hour. Attend pumps, flumes, and product flow of in-stage distribution system--30,000 pounds per hour.

g/ Trays fed by bulk fill attendant at this output rate.

TABLE S-7

Frozen Lima Bean and Green Pea Plants--Packaging Stages: Equipment Requirements in Relation to Selected Rates of Output and Styles of Pack California, 1960

Rates of output[a/]	Retail style								Institutional style							
	Pneumatic separator[b/]		Accumulating hopper[c/]		Vibrator feeder[d/]	Filling equipment[e/]		Wrapping equipment[f/]	Pneumatic separator[b/]		Accumulating hopper[c/]		Vibrator feeder[d/]	Filling equipment[g/]		Wrapping equipment[h/]
pounds per hour	number	type	number	type	number	number	type	number	number	type	number	type	number	number	type	number
5,000	1	A	1	A	1	1	A	1	1	A	1	A	1	1	C	1
10,000	1	B	1	A	1	1	B	2	1	B	1	A	1	1	C	1
15,000	1	D	1	B	2	2	A	2	1	D	2	A	2	2	C	2
20,000	1	E	2	A	2	1 1	A B	3	1	E	2	A	2	2	C	2
25,000	2	C	2	A	3	3	A	4	2	C	2	A	2	2	C	2
30,000	2	D	2	B	3	2 1	A B	4	2	D	3	A	3	3	C	3

Rates of output[a/]	Bulk style						In-stage distribution			
	Pneumatic separator[b/]		Tray-fill assembly[i/]	Cluster separator[j/]	Spiral conveyor[k/]	Bag or case filler[l/]	Pump assembly[m/]	Tubing[n/]	Flumes[o/]	Dewater reels[p/]
pounds per hour	number	type	number	number	number	number	number	feet	feet	number
5,000	1	A	1	1	1	1	2	60	40	3
10,000	1	B	1	1	1	1	3	60	40	3
15,000	1	D	2	2	2	2	3	60	80	6
20,000	1	E	2	2	2	2	3	60	80	6
25,000	2	C	3	3	3	3	3	70	90	7
30,000	2	D	3	3	3	3	3	90	110	9

a/ Pack-out basis.

b/ Five types: Type A--18-inch intake; 3-h.p. motor; 7,500-pounds-per-hour capacity; installed--$1,488. Type B--24-inch intake; 7½-h.p. motor, 10,000-pounds-per-hour capacity; installed--$2,6[illegible]8. Type C--30-inch intake; 7½-h.p. motor; 12,500-pounds-per-hour capacity; installed--$2,788. Type D--36-inch intake; 7½- to 10-h.p. motor; 15,000-pounds-per-hour capacity; installed--$3,050. Type E--42-inch intake; 7½- to 10-h.p. motor; 20,000-pounds-per-hour capacity; installed--$3,136.

c/ Two sizes: Type A--45 cubic feet; conical or tetrahedral--$175. Type B--108 cubic feet; conical or tetrahedral--$358.

d/ 3/4-h.p. motor; 10,000-pounds-per-hour capacity; custom built--$475.

e/ Two types: Type A--volumetric; with leased carton-forming and closing attachments; 7,500-pounds-per-hour capacity; installed--$4,065. Lease equipment--$13,27[illegible], payable in annual installments over a 10-year period. Type B--volumetric; with integrated carton-forming and closing equipment; 10,000-pounds-per-hour capacity; wholly leased--$21,150, payable in annual installments over a 10-year period.

f/ 7,500-pounds-per-hour capacity; installed--$12,245, including tray-off attachment.

g/ Volumetric fill with leased carton-forming and closing attachments; 12,750-pounds-per-hour capacity; installed--$4,065. Lease equipment--$13,277 payable in annual installments over a 10-year period.

h/ 12,750-pounds-per-hour capacity; installed--$10,500, including tray-off attachment.

i/ Includes tray-fill hopper, vibrator feed mechanism, powered roller conveyor (cleated for trays), two-speed motor and drive assembly, and take-off skate-wheel conveyor; 10,000-pounds-per-hour capacity; custom built and installed--$1,823.

j/ 1-h.p. motor; 10,000-pounds-per-hour capacity; custom built and installed--$1,200.

k/ Each conveyor 15 feet long with 9-inch screw; enclosed; 1-h.p. motor and drive; installed--$498.

l/ Manually operated; includes hopper, spiral feed mechanism, shear gate, and hand lever; custom built and installed--$672.

m/ Pump assembly and intake tank; 3-inch pump; 12,000-pounds-per-hour capacity; installed--$695.

n/ Includes 3-inch polyethylene tubing and fittings, flumes, dividers, chutes, and waste water disposal tubes.

o/ Galvanized iron, unseamed construction, 20 gauge, 7 inch; installed--$7.00 per foot.

p/ Installed--$375.

TABLE S-8

Frozen Brussels Sprouts Plants--Preparation Stages: Crew Requirements
in Relation to Selected Rates of Output
California, 1960

Rates of output a/	Equipment attendants					Manual quality grading d/
	Trimmers b/	Size graders c/	Hydrouts c/	Blanchers c/	Boilers c/	
pounds per hour	number of workers					
2,000	$0.1904P_1 + 0.1176P_2 + 0.0834P_3$	1	1	1	1	$3.884 + 0.1312\bar{p}$
4,000	$0.3808P_1 + 0.2352P_2 + 0.1668P_3$	1	1	1	1	$5.668 + 0.2624\bar{p}$
6,000	$0.5712P_1 + 0.3528P_2 + 0.2502P_3$	1	1	1	1	$7.472 + 0.3936\bar{p}$
8,000	$0.7616P_1 + 0.4704P_2 + 0.3336P_3$	1	1	1	1	$9.236 + 0.5248\bar{p}$
10,000	$0.9520P_1 + 0.5880P_2 + 0.4170P_3$	1	1	1	1	$11.020 + 0.6560\bar{p}$
12,000	$1.1424P_1 + 0.7056P_2 + 0.5004P_3$	2	2	2	2	$12.804 + 0.7872\bar{p}$
14,000	$1.3328P_1 + 0.8232P_2 + 0.5836P_3$	2	2	2	2	$14.588 + 0.9184\bar{p}$
16,000	$1.5232P_1 + 0.9408P_2 + 0.6672P_3$	2	2	2	2	$16.372 + 1.0496\bar{p}$
18,000	$1.7136P_1 + 1.0584P_2 + 0.7506P_3$	2	2	2	2	$18.156 + 1.1808\bar{p}$
20,000	$1.9040P_1 + 1.1760P_2 + 0.8340P_3$	2	2	2	2	$19.940 + 1.3120\bar{p}$

a/ Pack-out basis.

b/ P_1 is the percentage of total rate of output comprising size No. 2 sprouts, P_2 is the percentage of size No. 3, and P_3 is the percentage of size No. 4. Hourly wage of trimmers--$1.77.

c/ Labor production standards and wage rates: Size grader attendants--10,000 pounds per hour; hourly wage--$2.10. Hydrout and blancher attendants--10,000 pounds per hour; hourly wage--$2.28. Boiler attendants--10,000 pounds per hour; hourly wage--$2.86.

c/ Calculated from the equation $N = 2.100 + 0.892R + 0.065R\bar{p}$, where N is the number of manual quality graders, R is plant capacity in 1,000 pounds per hour, and $\bar{p}$ is manual grade-out percentage.

TABLE S-9

Frozen Brussels Sprouts Plants--Preparation Stages: Equipment Requirements in Relation to Selected Rates of Output
California, 1960

Rates of output[a]	Dump assembly[b]	Flight conveyors[c]		Size grade assembly: Size graders[d]		Size grade assembly: Cross conveyors[e]		Size grade assembly: Side conveyors[f]		Flight conveyors[c]		Cross conveyors[g]		Hydrout and trim table assembly[h]: Hydrouts[i]	Booster pumps[j]	Feeders[k]		1/4-inch tap lines[l]	Supply conveyors[m]		Work bins[n]	Collection conveyors[m]		Return conveyors[o]		Distribution conveyors[p]	
pounds per hour	number	number	feet	number	feet	number	feet	number	feet	number	feet	number	feet	number	number	size in inches	feet	feet	number	feet	number	number	feet	number	feet	number	feet
2,000	2	1	20	1	A	6	66	1	16	1	20	g/		18	1	1¼	35	36	1	25	18	1	25	2	33	1	10
4,000	2	1	20	1	B	6	72	1	16	1	20			35	1	1½	60	70	1	50	35	1	50	2	58	1	10
6,000	3	1	20	1	B	6	72	2	32	2	40	1	20	52	2	1½	90	104	2	70	52	2	70	3	63	2	20
8,000	3	1	20	2	A	6	96	2	32	2	40	1	20	69	2	1½	115	138	2	95	69	2	95	3	76	2	20
10,000	3	1	20	1 1	A B	6	102	2	32	2	40	1	20	86	2	1½	135	172	3	115	86	3	115	5	112	3	50
12,000	4	2	40	2	B	6	108	2	32	2	40	1	48	103	4	1½	183	204	4	143	103	4	143	5	128	3	50
14,000	4	2	40	2 1	A B	6	132	2	32	2	40	1	48	120	4	1½	200	240	4	160	120	4	160	6	138	4	60
16,000	4	2	40	4	A	6	156	2	32	2	40	1	48	138	4	1½	223	276	4	183	138	4	183	6	152	4	60
18,000	4	2	40	3 1	A B	6	162	2	32	2	40	1	48	155	4	1½	243	310	4	203	155	4	203	6	160	4	60
20,000	4	2	40	4	B	6	180	2	32	2	40	1	48	172	4	2	264	344	4	224	172	4	224	6	172	4	60

Rates of output	Pneumatic separators[r]		Flight conveyors[c]		Wash assembly[s]: Type A	Wash assembly[s]: Type B	Conveyors[t]		Blanch assembly[u]: Type A		Blanch assembly[u]: Type B		Flumes[v]	Conveyors[w]		Steam data: Boilers[x]	Steam data: Steam	Steam data: Heating surface	Inspection conveyors[y]	
pounds per hour	number	type	number	feet	number	number	number	feet	number	feet	number	feet	feet	number	feet	horsepower	pounds	square feet	number	feet
2,000	1	A	1	8	1	1	1	10	1	20			50	1	12	20	690	108	1	10
4,000	1	A	1	8	1	1	1	10	1	40			75	1	12	20	690	108	1	15
6,000	2	A	2	16	2	2	2	20	2	60			120	2	24	50	1,725	270	2	20
8,000	2	A	2	16	2	2	2	20	2	80			140	2	24	50	1,725	270	2	23
10,000	2	A	2	16	2	2	2	20			2	74	160	2	24	50	1,725	270	2	26
12,000	2	B	2	16	2	2	2	20			2	90	180	2	24	74	2,453	400	2	30
14,000	2	B	2	16	2	2	2	20			2	104	200	2	24	74	2,453	400	2	36
16,000	2	C	2	16	2	2	2	20			2	120	220	2	24	74	2,453	400	2	40
18,000	2	C	2	16	2	2	3	30			3	135	240	3	36	81	2,794	437	3	45
20,000	2	D	2	16	2	2	3	30			3	156	260	3	36	81	2,794	437	3	51

(Continued on next page.)

Table S-9, continued.

a/ Pack-out basis. For output rate flexibility, Hydrout and trimming equipment requirements are based on a size distribution of 80 percent size No. 2 sprouts (3/4 to 1-1/8 inch base diameter), while other equipment is synthesized on the basis of a size distribution of 90 percent size No. 4 sprouts (1-1/4 to 1-3/8 inch base diameter).

b/ Cradle-type mechanical bin dumper and dump hopper; 1/2-h.p. motor and drive; 14,000-pounds-per-hour capacity. Dump assembly is of custom or plant manufacture; installed--$911. For output rates below 6,000 pounds per hour, one dumper for ungraded sprouts and one fnr graded sprouts; for output rates from 6,000 to 12,000 pounds per hour, one dumper for ungraded sprouts and two for graded sprouts; for nutput rates above 12,000 pounds per hour, two dumpers each for graded and ungraded sprouts.

c/ 12" x indicated lengths; 6-inch cleats, 6 inches on center; 40-degree incline; 12-feet discharge height; 3/4-h.p. motor and drive; installed--$547 +$15L, where L is the length of conveyor frame in feet.

d/ Diverging rod-type sizer mounted on shaker-frame assembly; nibble rods between sizing channels for positioning of sprouts. Four size categories: No. 2--3/4 to 1-1/8 inches; No. 3--1-1/8 to 1-1/4 inches; No. 4--1-1/4 to 1-3/8 inches; and No. 5--over 1-3/8 inches. Graders are of two types and are installed side by side for larger capacity. Type A--4' x 6'; 5,000-pounds-per-hour capacity; 1-h.p. motor and drive; custom built and installed--$4,075. Type B--5' x 6'; 8,000-pounds-per-hour capacity; 1-h.p. motor and drive; custom built and installed--$4,420.

e/ Six 12-incb conveyors: one for distributing or spreading incoming sprouts to size separating rods, four for graded sprouts, and one for graded sprout collection; installed--$347 + $10.30L each.

f/ Side delivery conveyor; 12" x 16', for collection at delivery spouts and redumping bins. For output rates below 6,000 pounds per hour, one conveyor; for output rates above 6,000 pounds per hour, two conveyors; installed--$347 + $10.30L each.

g/ To trimmer supply lines; 18" x indicated lengths; installed--$347 + $15L each.

h/ Add 25 percent installation and 10 percent contingencies to unit equipment costs of the Hydrout and trim table assembly.

i/ Number of Hydrouts based on a size distribution of 80 percent size No. 2 sprouts and a trimming standard of 85 sprouts per minute (116 pounds per hour) per trimmer; installed--$68 each, including tax. The Hydrout is a trimmer manufactured by Magnuson Engineers, Inc.

j/ To boost plant water pressure to approximately 200 pounds per square inch per Hydrout. Two-stage centrifugal-type motors, 7½ to 20 h.p. Pump prices, including tax: 7½ h.p.--$452; 10 h.p.--$586; 15 h.p.--$741; and 20 h.p.--$819.

k/ Feeder pipelines of diameters and lengths indicated to deliver water to each Hydrout tap line. Length of feeder lines calculated at 10 feet longer than each trim line. Costs per foot estimated as follows: 1¼ inch--39 cents; 1½ inch--46 cents; and 2 inch--63 cents. Cost of valves, elbows, tees, plugs, threaded outlets, and other fittings is included in total cost estimates given in the text.

l/ To Hydrout hose attachment, estimated at 2 feet per Hydrout.

m/ To trimmer supply bins; 24" x indicatad lengths; installed--$347 + $10.30L each.

n/ 28" x 8" deep; 25-degree incline; supplied by overhead conveyor; installed--$3.40 per square foot of surface area.

o/ Includes 8-inch cross, return, and flight conveyors for returning untrimmed sprout overflow to trimmers' supply belt; installed--$347 + $10.30L each.

p/ To pneumatic separators (deleafing). For output rates below 6,000 pounds per hour, the conveyor is a continuation of the trim table collection conveyor; installed--$15.30L. For output rates from 6,000 to 10,000 pounds per hour, both conveyors are continuations of the trim table collection conveyor; installed--$15.30L. For output rates from 10,000 to 14,000 pounds per hour, one 12" x 30' cross conveyor, sheared to two delivery conveyors, each 12" x 10'. For output rates above 14,000 pounds per hour, the cross conveyor is 40 feet in length and the two delivery conveyors are 12" x 10' each. Installed costs--$347 + $15.30L (cross conveyors) and $280 + $15.30L (delivery conveyors).

q/ Blanks indicate does not apply.

r/ For daleafing. Type A--18-inch intake; 3 h.p.; 5,625-pounds-per-hour capacity; installed--$1,488. Type B--24-inch intake; 7½ h.p.; 7,500-pounds-per-hour capacity; installed--$2,698. Type C--30-inch intake; 7½ to 10 h.p.; 9,400-pounds-per-hour capacity; installed--$2,788. Type D--36-inch intake; 10 h.p.; 11,250-pounds-per-hour capacity; installed--$3,050.

s/ Flood-type washers; Types A and B in tandem. Type A--42" x 16'; galvanized woven wire draper with 1-h.p. motor and drive; welded steel tank with 10-h.p. booster and recirculating pump; overhead pressure nozzles; custom built and installad--$4,172. Type B--same as Type A except tank is 42" x 22' and pump is 20 h.p.; custom built and installed--$5,749.

t/ To blanchers. For output rates of 18,000 pounds per hour and over, a 42" x 10' cross conveyor is required to deliver to a third blancher. Installed--$547 + $20L (flight conveyors) and $347 + $15.30L (cross convayors).

u/ Requirements based on a 4-minute blanching time. Type A--36-inch galvanized woven wire draper; enclosed welded steel tank; two 1-inch water inlets; two 2-inch steam inlets; two exhaust stacks; two 3-inch drains; 3-h.p. variable-speed motor and drive; maximum length with two steam banks, 60 feet. Cost per blanching unit ($3,416) is estimated on the basis of standard 30-foot length less $86 per foot of length less than 30 feet and plus $114 per foot of length more than 30 feet. Total installed cost includes dual temperature-control installation--$686; tax--3 percent; contingencies--10 percent; installatinn; and freight. Type B--same as Type A unit except draper is 48 inches. Cost per Type B blanching unit ($4,416) is estimated on the basis of standard 30-foot length less $111 per foot of length less than 30 feet and plus $148 per foot of length more than 30 feet. Other costs are the same as for Type A unit.

v/ Galvanized iron; 20 gauge; unseamed; installed--$7.00 per foot.

w/ Mesh belting; dewater; installed--$547 + $20L.

x/ Includes 125-pounds-per-square-inch Scntch marine dryback boiler, forced draft natural gas burner, feed-pump assembly, trim and fittings, and lagging and stack. Does not include steam piping and fittings to plant outlets. Installed costs of boiler units: 20 h.p.--$3,063; 50 h.p.--$4,313; 74 h.p.--$5,594; and 81 h.p.--$7,219.

y/ 24" x indicated lengths, with 6-inch tracks for placing grade-out, with chutes to floor trench for defects and to buckets for improperly trimmed sprouts; each belt is a minimum of 10 feet in length; complete with flanged edges and 1-h.p. motor and drive; custom built and installed--$547 + $20L.

TABLE S-10

Frozen Brussels Sprouts Plants--Packaging Stages: Crew Requirements in Relation to Selected Rates of Output, Styles of Pack, and Methods Used
California, 1960

Rates of output a/	Retail style b/							Institutional style												
								Method A c/							Method B d/					
	Feed cartons	Attend fill	Weigh	Supply materials	Truck skids	Tray off	Total	Feed cartons	Attend fill	Weigh	Supply materials	Truck skids	Tray off	Total	Form and fill	Weigh and close	Supply materials	Truck skids	Tray off	Total
pounds per hour	number of workers																			
2,000	-- e/	1	3	1	1	1	7	--	1	2	--	1	1	5	4	4	1	1	1	11
4,000	1	2	5	1	1	2	12	1	1	4	1	1	1	9	8	8	2	1	1	20
6,000	2	4	8	1	1	2	18	1	1	6	1	1	1	11	12	12	3	1	1	29
8,000	2	4	10	1	1	3	21	1	1	8	1	1	2	14	16	16	3	1	2	38
10,000	2	4	13	1	1	4	25	1	1	10	1	1	2	16	20	20	3	1	2	46
12,000	3	6	15	1	1	4	30	2	2	12	1	1	2	20	24	24	4	1	2	55
14,000	3	6	18	2	2	5	36	2	2	14	2	1	3	24	28	28	4	1	3	64
16,000	4	8	20	2	2	5	41	2	2	16	2	1	3	26	32	32	5	1	3	74
18,000	4	8	23	2	2	6	45	2	2	18	2	1	3	28	36	36	6	1	3	82
20,000	4	8	26	2	2	7	49	2	2	20	2	1	4	31	40	40	6	1	4	91

a/ Converted to pounds per hour on the basis of 10-ounce retail cartons and $2\frac{1}{2}$-pound institutional cartons.

b/ Labor production standards and wage rates--retail style: Feed cartons--one worker required for each carton-forming assembly; 5,000 pounds per hour; hourly wage--$1.77. Attend fill--supply product to fill pockets on semiautomatic filler; 2,500 pounds per hour; hourly wage--$1.77. Weigh--the standard for hand weighing varies according to the position of the worker in the weigh line as given in the following equation: $Y = 1{,}042.9 - 70.10X$, where Y is pounds per worker hour and X is the line position of the worker; hourly wage--$1.77. Supply materials and truck skids--12,200 pounds per hour; hourly wage--$1.94. Tray off--3,200 pounds per hour; hourly wage--$1.94.

c/ Labor standards and wage rates--institutional style (Method A): Wage rates are the same as for retail style. Feed cartons and attend fill--10,000 pounds per hour. Weigh--1,000 pounds per hour. Supply materials--20,000 pounds per hour. Truck skids--12,200 pounds per hour. Tray off--6,400 pounds per hour.

d/ Labor standards and wage rates--institutional style (Method B): Wage rates are the same as for retail style. Form and fill; weigh and close--500 pounds per hour; hourly wage--$1.77. Supply materials--20,000 pounds per hour. Truck skids--3,500 pounds per hour. Tray off--6,400 pounds per hour.

e/ Dashes indicate job performed by another worker at this output rate.

TABLE S-11

Frozen Brussels Sprouts Plants--Packaging Stages: Equipment Requirements in Relation to Selected Rates of Output, Styles of Pack, and Methods Used
California, 1960

Rates of output[a/] (pounds per hour)	Scales and pans[b/] (number)	Retail style: Flight conveyors[c/] number	Retail style: Flight conveyors[c/] feet	Retail style: Weigh lines[d/] number	Retail style: Weigh lines[d/] feet	Retail style: Carton equipment[e/] (number)	Retail style: Fillers[f/] (number)	Retail style: Wrappers[g/] (number)	Institutional, Method A: Cross conveyors[h/] number	Institutional, Method A: Cross conveyors[h/] feet	Institutional, Method A: Flight conveyors[i/] number	Institutional, Method A: Flight conveyors[i/] feet	Institutional, Method A: Weigh lines[d/] number	Institutional, Method A: Weigh lines[d/] feet	Institutional, Method A: Carton equipment[j/] (number)	Institutional, Method A: Fillers[k/] (number)	Institutional, Method A: Wrappers[l/] (number)	Institutional, Method B: Cross conveyors[h/] number	Institutional, Method B: Cross conveyors[h/] feet	Institutional, Method B: Flight conveyors[i/] number	Institutional, Method B: Flight conveyors[i/] feet	Institutional, Method B: Pack lines[m/] number	Institutional, Method B: Pack lines[m/] feet	Institutional, Method B: Weigh lines[d/] number	Institutional, Method B: Weigh lines[d/] feet	Institutional, Method B: Wrappers[l/] number
2,000	6	1	10	1	10	1	1	1	1	10	1	10	1	10	1	1	1	1	10	1	10	1	8	1	8	1
4,000	10	1	10	1	15	1	1	1	1	10	1	10	1	10	1	1	1	1	10	1	10	1	14	1	14	1
6,000	16	2	20	2	24	2	2	2	1	20	1	10	1	10	1	1	1	1	20	1	10	1	20	1	20	1
8,000	20	2	20	2	30	2	2	2	1	20	1	10	1	15	1	1	1	1	20	1	10	1	25	1	25	1
10,000	24	2	20	2	40	2	2	2	1	20	1	10	1	15	1	1	1	1	20	1	10	1	31	1	31	1
12,000	30	3	30	3	45	3	3	3	1	38	2	20	2	20	2	2	2	1	38	1	10	1	36	1	36	1
14,000	36	3	30	3	48	3	3	3	1	38	2	20	2	20	2	2	2	1	38	2	20	2	44	2	44	2
16,000	40	4	40	4	56	4	4	4	1	48	2	20	2	24	2	2	2	1	48	2	20	2	49	2	49	2
18,000	46	4	40	4	64	4	4	4	1	48	2	20	2	30	2	2	2	1	48	2	20	2	54	2	54	2
20,000	50	4	40	4	76	4	4	4	1	48	2	20	2	32	2	2	2	1	48	2	20	2	62	2	62	2

a/ Pack-out basis.

b/ Scales of 3-pound capacity; 1 ounce over and under by 1/4-ounce dial; knife-edge pivots; platter and base of polished cast aluminum; anticorrosion treated; delivered--$176 each. Product pans, aluminum; $2.00 each.

c/ To retail fill hopper; 12" x indicated lengths; installed--$547 + $15L, where L is the length of conveyor frame in feet.

d/ Two conveyors, each 6" x indicated lengths, with integrated weighing stands. Filled carton delivery conveyor is 2 to 3 inches above scale platters; installed--$1,094 + $50L. As scales are adaptable for either retail or institutional carton weighing, they are considered separately (see footnote b).

e/ Kliklok-type carton-forming, Prespak, and closing sections; 7,500-pounds-per-hour capacity; 10-year rental--$18,186.

f/ Straight line; semiautomatic; 5,000-pounds-per-hour capacity; installed--$4,065.

g/ 7,500-pounds-per-hour capacity; installed--$12,245.

h/ To institutional filling lines. For output rates below 6,000 pounds per hour, 12 inches, with 3/4-h.p. drive. For output rates from 6,000 to 12,000 pounds per hour, 15 inches, with 1-h.p. drive. For output rates from 12,000 to 16,000 pounds per hour, 18 inches, with 1-h.p. drive. For output rates above 16,000 pounds per hour, 24 inches, with 1-h.p. drive. Installed costs: 3/4-h.p. drive--$280 + $15L; 1-h.p. drive--$347 + $15L.

i/ To institutional fill hopper; 12" x indicated lengths; installed--$547 + $15L.

j/ Kliklok-type carton-forming, Prespak, and closing sections; 10,000-pounds-per-hour capacity; 10-year rental--$17,426.

k/ Straight line; semiautomatic; 10,000-pounds-per-hour capacity; installed--$4,065.

l/ 12,750-pounds-per-hour capacity; installed--$10,500.

m/ One product conveyor, 30" x length of table, with two 6-inch tracks for cartons; installed--$1,094 + $50L.

TABLE S-12

Frozen Broccoli Plants--Trimming Stages: Equipment Requirements and Replacement Costs in Relation to Selected Rates of Output and Methods Used
California, 1960

Rates of output a/	Bin supply method								Conveyor supply method									
	Tubs and frames b/	Supply conveyors c/		Collection conveyors d/		Waste conveyors e/		Total replacement cost f/	Trim table assembly g/		Cross conveyors h/		Return conveyors i/		Waste conveyors e/		Total replacement cost f/
pounds per hour	square feet	number	feet	number	feet	number	feet	dollars	number	feet	number	feet	number	feet	number	feet	dollars
2,000	140	1	25	1	25	1	30	4,650	1	25	j/	j/	1	33	2	55	5,124
4,000	265	1	48	1	48	1	30	6,271	2	50	1	15	1	40	3	80	8,783
6,000	400	1	70	1	70	1	30	7,787	3	75	1	25	1	50	4	105	12,127
8,000	550	2	96	2	96	1	45	11,706	4	100	2	30	2	80	5	145	17,110
10,000	680	2	116	2	116	1	45	13,100	5	125	2	40	2	90	6	170	20,404
12,000	800	2	140	2	140	1	45	14,774	6	150	2	50	2	100	7	195	23,747
14,000	945	2	160	2	160	1	45	16,108	7	175	2	55	2	105	8	220	26,904
16,000	1,050	3	189	3	189	1	60	19,949	8	200	3	65	3	140	9	260	31,678
18,000	1,200	3	210	3	210	1	60	21,412	9	225	3	75	3	150	10	285	35,052
20,000	1,360	3	234	3	234	1	60	23,066	10	250	3	80	3	155	11	311	38,176

a/ Pack-out basis. A natural recovery rate of 80 percent is assumed.

b/ Worker supply bins 28" wide x 8" deep, 25-degree incline, installed--$3.40 per square foot of surface area, including chutes, cutting stands, and welded iron table frame.

c/ Includes two supply belts 12" x indicated lengths, off one 1-h.p. motor and drive; installed--$547 + $15.30L, where L is the length of conveyor frame in feet.

d/ For collection of trimmed spears; 30" x indicated lengths; 1-h.p. motor and drive; installed--$547 + $15.30L.

e/ To garbage hopper or truck; 12" x indicated lengths; 6-inch flights; 1-h.p. motor; installed--$547 + $15.30L.

f/ Includes equipment and belting.

g/ Includes a 24-inch delivery conveyor, an 18-inch collection conveyor, and an 8- to 12-inch waste conveyor; disposal chutes and cutting stands. Custom built and installed--$969 + $40L.

h/ 12" x indicated lengths; 3/4-h.p. motor and drive; installed--$280 + $15.30L.

i/ For returning excess supply of untrimmed broccoli to trimmers; 12" x indicated lengths; installed cost--$347 + $10.30L.

j/ Does not apply.

TABLE S-13

Frozen Broccoli Plants--Preparation Stages: Crew Requirements in Relation to Selected Rates of Output California, 1960

Rates of output a/	Crew requirements b/						
	Receive	Grower grade	Distribute to trimmer	Trim	Attend blanchers	Attend boilers	Total
pounds per hour	number of workers						
2,000	1	1	1	19	1	1	24
4,000	1	1	1	37	1	1	42
6,000	1	2	1	55	1	1	61
8,000	2	2	1	73	1	1	80
10,000	2	3	2	91	1	1	100
12,000	2	3	2	110	2	2	121
14,000	2	4	2	129	2	2	141
16,000	3	4	2	146	2	2	159
18,000	3	5	3	164	2	2	179
20,000	3	5	3	182	2	2	197

a/ Pack-out basis. A natural recovery rate of 80 percent is assumed.

b/ Labor production standards and wage rates: Receive and attend dumping--6,000 pounds per hour; hourly wage--$1.94. Grower grade--4,000 pounds per hour; hourly wage--$1.77. Distribute product to trimmer bins--8,000 pounds per hour; hourly wage--$1.77. Trim--standard based on U. S. Grade A specifications; 110 pounds per trimmer hour; hourly wage--$1.77. Attend blanchers--10,000 pounds per hour; hourly wage--$2.28. Attend boilers--10,000 pounds per hour; hourly wage--$2.86.

TABLE S-14

Frozen Broccoli Plants--Preparation Stages: Equipment Requirements in Relation to Selected Rates of Output
California, 1960

Rates of output a/	Dump station b/	Distribution conveyors: Apron c/		Cross d/		Flight e/		Trim table f/: Tubs and frames g/	Supply conveyors h/		Collection conveyors i/		Waste conveyors j/		Conveyors k/		Wash assembly l/: Type A	Type B	Conveyors m/		Blanch assembly n/: Type A		Type B		Cooling tanks o/	Conveyors p/		Steam data: Boilers q/	Steam	Heating surface
pounds per hour	number	number	feet	number	feet	number	feet	square feet	number	feet	number	feet	number	feet	number	feet	number	number	number	feet	number	feet	number	feet	number	number	feet	horsepower	pounds	square feet
2,000	1	1	8	1	10	1	15	140	1	25	1	25	1	30	1	8	1	1	1	10	1	20	r/		1	1	10	20	690	108
4,000	1	1	8	1	10	1	15	265	1	48	1	48	1	30	1	8	1	1	1	10	1	40			1	1	10	20	690	108
6,000	1	1	8	1	10	1	15	400	1	70	1	70	1	30	1	8	1	1	1	10			1	45	1	1	10	50	1,725	270
8,000	2	2	16	2	20	2	30	550	2	96	2	96	1	45	2	16	2	2	2	20	2	60			2	2	20	50	1,725	270
10,000	2	2	16	2	20	2	30	680	2	116	2	116	1	45	2	16	2	2	2	20			2	74	2	2	20	50	1,725	270
12,000	2	2	16	2	20	2	30	800	2	140	2	140	1	45	2	16	2	2	2	20			2	90	2	2	20	74	2,453	400
14,000	2	2	16	2	20	2	30	945	2	160	2	160	1	45	2	16	2	2	2	20			2	104	2	2	20	74	2,453	400
16,000	3	3	24	3	30	3	45	1,050	3	189	3	189	1	60	3	24	2	2	3	66			3	135	3	3	30	74	2,453	400
18,000	3	3	24	3	30	3	45	1,200	3	210	3	210	1	60	3	24	2	2	3	66			3	135	3	3	30	81	2,794	437
20,000	3	3	24	3	30	3	45	1,360	3	234	3	234	1	60	3	24	2	2	3	66			3	156	3	3	30	81	2,794	437

a/ Pack-out basis. A natural recovery rate of 80 percent is assumed.

b/ Cradle-type mechanical dump--1/2 to 3/4 h.p.; 7,500-pounds-per-hour capacity; custom built and installed--$690.

c/ 8' x 10'; 3-inch cleats; 8-inch sidings; 1-h.p. motor and drive; installed--$547 + $15.30L, where L is the length of conveyor frame in feet.

d/ 12" x 10'; 6-inch sidings; 3/4-h.p. motor and drive; installed--$280 + $15.30L.

e/ To trim tables; 18" x 15'; 3-inch flights; 3/4-h.p. motor and drive; installed--$280 + $15.30L.

f/ Complete with worker supply bins, delivery conveyor, distribution assembly, disposal chutes, and collection conveyor.

g/ Worker supply bins 28" wide x 8" deep, 25-degree incline; installed--$3.40 per square foot of surface area, including chutes, cutting stands, and welded iron table frame.

h/ Includes two supply belts, 12" x indicated lengths, off one 1-h.p. drive; installed--$547 + $15.30L.

i/ For collection of trimmed spears; 30" x indicated lengths; 1-h.p. motor and drive; installed--$547 + $15.30L.

j/ To garbage hopper or truck; 12" x indicated lengths; 6-inch flights; 1-h.p. motor and drive; installed--$547 + $15.30L.

k/ To washers; 24" x 8' each; 3/4-h.p. motor and drive; installed--$280 + $15L.

l/ Flood-type washers; Types A and B in tandem. Type A--42" x 16'; galvanized woven wire draper with 1-h.p. motor and drive; welded steel tank with 10-h.p. booster and recirculating pump; overhead pressure nozzles; custom built and installed--$4,172. Type B--same as Type A except tank is 42" x 22' and pump is 20 h.p.; custom built and installed--$5,749.

m/ To blanchers; 42" x indicated lengths. For output rates below 8,000 pounds per hour, one 10-foot conveyor; 3/4-h.p. motor and drive; installed--$280 + $15L. For output rates from 8,000 to 16,000 pounds per hour, two 10-foot conveyors, each with 3/4-h.p. motor and drive; installed--$560 + $15L. For output rates above 16,000 pounds per hour, two 10-foot conveyors and a cross-conveyor assembly to deliver two lines to three blanchers; installed--$840 + $15L.

n/ Requirements based on a 4-minute blanching time. Type A--36-inch galvanized woven wire draper; enclosed welded steel tank; two 1-inch water inlets; two 2-inch steam inlets; two exhaust stacks; two 3-inch drains; 3-h.p. variable-speed motor and drive; maximum length with two steam banks, 60 feet. Cost per blanching unit ($3,416) is estimated on the basis of standard 30-foot length less $86 per foot of length less than 30 feet and plus $114 per foot of length more than 30 feet. Total installed cost includes dual temperature-control installation--$686; tax--3 percent; contingencies--10 percent; installation; and freight. Type B--same as Type A unit, except draper is 48 inches. Cost per Type B blanching unit ($4,416) is estimated on the basis of standard 30-foot length less $111 per foot of length less than 30 feet and plus $148 per foot of length more than 30 feet. Other costs are the same as for Type A unit.

o/ Same type as Type A washer; installed--$4,172.

p/ To inspection line; galvanized wire mesh; 42" x indicated lengths; installed--$347 + $15.30L.

q/ Includes 125-pounds-per-square-inch Scotch marine dryback boiler, forced draft natural gas burner, feed-pump assembly, trim and fittings, and lagging and stack. Does not include steam piping and fittings to plant outlets. Installed costs of boiler units: 20 h.p.--$3,063; 50 h.p.--$4,313; 74 h.p.--$5,594; and 81 h.p.--$7,219.

r/ Blanks indicate does not apply.

TABLE S-15

Frozen Broccoli Plants--Packaging Stages: Crew Requirements in Relation to Selected Rates of Output, Styles of Pack, and Methods Used California, 1960

Broccoli spears

Rates of output[a]	Retail style[b] Feed cartons	Retail style[b] Inspect and pack	Retail style[b] Weigh	Retail style[b] Supply materials	Retail style[b] Truck skids	Retail style[b] Tray off	Retail style[b] Total	Institutional style[c] Feed cartons A	Feed cartons B	Inspect and pack A	Inspect and pack B	Weigh A	Weigh B	Supply materials A	Supply materials B	Truck skids A	Truck skids B	Tray off A	Tray off B	Total A	Total B
pounds per hour	number of workers																				
2,000	--[d]	5	4	1	1	1	12	--	[e]	5	5	4	4	--	1	1	1	1	1	11	12
4,000	1	10	8	1	1	2	23	1		6	9	6	8	1	2	1	1	1	1	16	21
6,000	1	17	14	1	1	2	36	1		8	14	8	12	1	3	1	1	1	1	20	31
8,000	2	20	16	1	1	3	43	1		11	18	11	16	1	3	1	1	2	2	27	40
10,000	2	27	22	1	1	4	57	1		13	23	13	20	1	3	1	1	2	2	31	49
12,000	2	34	28	1	1	4	70	1		16	27	16	24	1	4	1	1	2	2	37	58
14,000	2	43	36	2	2	5	90	2		18	32	18	28	2	4	1	1	3	3	44	68
16,000	3	44	36	2	2	5	92	2		21	36	21	32	2	5	1	1	3	3	50	77
18,000	3	51	42	2	2	6	106	2		24	40	24	36	2	6	1	1	3	3	56	86
20,000	3	58	48	2	2	7	120	2		26	45	26	40	2	6	1	1	4	4	61	96

Chopped broccoli

Rates of output[a]	Retail style[f] Feed cartons	Retail style[f] Attend fill	Retail style[f] Check-weigh	Retail style[f] Supply materials	Retail style[f] Truck skids	Retail style[f] Tray off	Retail style[f] Total	Institutional style[g] Feed cartons	Institutional style[g] Attend fill	Institutional style[g] Check-weigh	Institutional style[g] Supply materials	Institutional style[g] Truck skids	Institutional style[g] Tray off	Institutional style[g] Total
pounds per hour	number of workers													
2,000	--	1	2	1	1	1	6	--	1	2	1	1	1	6
4,000	1	2	3	1	1	2	10	1	1	3	1	1	1	8
6,000	1	3	4	1	1	2	12	1	1	4	1	1	1	9
8,000	2	4	5	1	1	3	16	1	1	5	1	1	2	11
10,000	2	4	7	1	1	4	19	1	1	7	1	1	2	13
12,000	2	5	7	1	1	4	20	2	2	7	1	1	2	15
14,000	2	6	9	2	2	5	26	2	2	9	2	1	3	19
16,000	3	7	10	2	2	5	29	2	2	10	2	1	3	20
18,000	3	8	11	2	2	6	32	2	2	11	2	1	3	21
20,000	3	8	12	2	2	7	34	2	2	12	2	1	4	23

a/ Converted to pounds per hour on the basis of 10-ounce retail cartons and $2\frac{1}{2}$-pound institutional cartons.

b/ Labor production standards and wage rates--retail style broccoli spears: Feed cartons--machine paced, one worker required per each carton former; 7,500 pounds per hour; hourly wage--$1.77. Inspect and pack; weigh--the standard for hand packing and hand weighing varies according to the position of the worker in the packing and weighing lines as given in the following equation: $Y = 603.0 - 39.67X$, where Y is pounds per worker hour and X is the line position of the worker; hourly wage--$1.77. Supply materials and truck skids--12,000 pounds per hour; hourly wage--$1.94. Tray off to freezer skid--3,200 pounds per hour; hourly wage--$1.94.

c/ Labor production standards and wage rates--institutional style broccoli spears (Method A): Wage rates are the same as for retail style broccoli spears. Feed cartons--12,000 pounds per hour. Inspect and pack; weigh--775 pounds per hour. Supply materials--12,000 pounds per hour. Truck skids--20,000 pounds per hour. Tray off--6,375 pounds per hour.

Labor production standards and wage rates--institutional style broccoli spears (Method B): Wage rates are the same as for retail style broccoli spears. Feed cartons--does not apply with this method. Inspect and pack--450 pounds per hour. Weigh and close cartons--500 pounds per hour. Supply materials--3,500 pounds per hour. Truck skids--20,000 pounds per hour. Tray off--6,375 pounds per hour.

d/ Dashes indicate job performed by another worker at this output rate.

e/ Blanks indicate does not apply.

f/ Labor production standards and wage rates--retail style chopped broccoli: Feed cartons--7,500 pounds per hour; hourly wage--$1.77. Attend machine fill--2,500 pounds per hour; hourly wage--$1.77. Check-weigh--3,050 pounds per hour; hourly wage--$1.77. Supply materials and truck skids--12,000 pounds per hour; hourly wage--$1.94. Tray off--3,200 pounds per hour; hourly wage--$1.94.

g/ Labor production standards and wage rates--institutional style chopped broccoli: Wage rates are the same as for retail style chopped broccoli. Feed cartons and attend machine fill--10,000 pounds per hour. Check-weigh--3,050 pounds per hour. Supply materials--12,000 pounds per hour. Truck skids--20,000 pounds per hour. Tray off--6,375 pounds per hour.

TABLE S-16

Frozen Broccoli Plants--Packaging Stages: Equipment Requirements in Relation to Selected Rates of Output, Styles of Pack, and Methods Used
California, 1960

BROCCOLI SPEARS — Retail style

Rates of output a/	Scales and pans b/	Inspection lines c/		Pack lines d/		Weigh lines e/		Carton equipment f/	Wrappers g/
pounds per hour	number	number	feet	number	feet	number	feet	number	number
2,000	4	1	8	1	8	1	8	1	1
4,000	8	1	8	1	12	1	12	1	1
6,000	14	1	8	1	20	1	20	1	1
8,000	16	2	16	2	24	2	24	2	2
10,000	22	2	16	2	30	2	30	2	2
12,000	28	2	16	2	40	2	40	2	2
14,000	36	2	16	2	50	2	50	2	2
16,000	36	3	24	3	51	3	51	3	3
18,000	42	3	24	3	60	3	60	3	3
20,000	48	3	24	3	66	3	66	3	3

BROCCOLI SPEARS — Institutional style, Method A

Rates of output a/	Distribution conveyors h/: Cross		Flight		Cross		Inspection and pack lines d/		Weigh lines e/		Carton equipment i/	Wrappers j/
pounds per hour	number	feet	number	feet	number	feet	number	feet	number	feet	number	number
2,000	1	8	1	10	k/		1	8	1	8	1	1
4,000	1	8	1	10			1	8	1	8	1	1
6,000	1	8	1	10			1	12	1	12	1	1
8,000	1	12	1	10			1	14	1	14	1	1
10,000	1	12	1	10			1	17	1	17	1	1
12,000	1	12	1	10			1	20	1	20	1	1
14,000	1	12	1	10	1	10	2	24	2	24	2	2
16,000	1	24	1	10	1	10	2	26	2	26	2	2
18,000	1	24	1	10	1	10	2	28	2	28	2	2
20,000	1	24	1	10	1	10	2	32	2	32	2	2

BROCCOLI SPEARS — Institutional style, Method B

Rates of output a/	Distribution conveyors g/: Cross		Flight		Cross		Inspection and pack lines d/		Weigh lines e/		Wrappers j/
pounds per hour	number	feet	number	feet	number	feet	number	feet	number	feet	number
2,000	1	8	1	10			1	8	1	8	1
4,000	1	8	1	10			1	14	1	12	1
6,000	1	8	1	10			1	20	1	17	1
8,000	1	12	1	10			1	25	1	22	1
10,000	1	12	1	10			1	31	1	27	1
12,000	1	12	1	10			1	36	1	32	1
14,000	1	12	1	10	1	10	2	44	2	39	2
16,000	1	24	1	10	1	10	2	49	2	44	2
18,000	1	24	1	10	1	10	2	54	2	49	2
20,000	1	24	1	10	1	10	2	62	2	54	2

CHOPPED BROCCOLI — Retail and institutional styles

Rates of output a/	Distribution: Flumes l/	Flight conveyors m/		Inspection and weigh lines n/		Carton equipment o/	Dicers or choppers p/	Fillers q/		Wrappers: Retail f/	Institutional j/
pounds per hour	feet	number	feet	number	feet	number	number	number	type	number	number
2,000	24	1	10	1	8	1	1	1	A	1	1
4,000	24	1	10	1	8	1	1	1	A	1	1
6,000	24	1	10	1	8	1	1	1	B	1	1
8,000	60	2	20	2	16	2	2	2	A	2	1
10,000	60	2	20	2	16	2	2	2	A	2	1
12,000	60	2	20	2	16	2	2	2	B	2	1
14,000	60	2	20	2	16	2	2	2	C	2	2
16,000	96	3	30	3	24	3	3	3	A	3	2
18,000	96	3	30	3	24	3	3	3	B	3	2
20,000	96	3	30	3	24	3	3	{2 1	C A}	3	2

a/ Pack-out basis.

b/ Scales of 3-pound capacity; 1 ounce over and under by 1/4-ounce dial; knife-edge pivots; platter and base of polished cast aluminum; anticorrosion treated; delivered--$176 each. Product pans, aluminum; $2.00 each. Common to all styles.

c/ 24" x indicated lengths; 3/4-h.p. motor and drive; installed--$280 + $15L, where L is the length of conveyor frame in feet.

d/ One product conveyor; 30" x length of table, with two 6-inch tracks for cartons; installed--$1,094 + $50L.

e/ Three carton conveyors, each 6" x indicated lengths; scales mounted between conveyors; installed--$1,094 + $50L.

f/ Kliklok-type carton-forming, Prespak, and closing sections; approximately 7,500-pounds-per-hour capacity; 10-year rental--$18,186.

g/ 7,500-pounds-per-hour capacity; installed--$12,245, including tray-off attachment.

h/ One cross conveyor, 12" x indicated lengths to 14,000 pounds per hour output rate; 15 inches thereafter; installed--$347 + $10.30L. One flight conveyor, 12" x indicated lengths to 14,000-pounds-per-hour output rate; 15 inches thereafter; installed--$547 + $15L. One cross conveyor to second packaging line; 15" x 10'; installed--$347 + $10.30L.

i/ Kliklok-type carton-forming, Prespak, and closing sections; approximately 12,750-pounds-per-hour capacity; 10-year rental--$17,426.

j/ 12,750-pounds-per-hour capacity; installed--$10,500, including tray-off attachment.

k/ Blanks indicate does not apply.

l/ 20-gauge galvanized iron, unseamed; installed--$7.00 per foot.

m/ To fill hopper; 12" x indicated lengths; 3-inch cleats or flights, 8 inches on center; installed--$547 + $15L.

n/ Installed-$1,094 + $50L.

o/ Convertible for retail and institutional cartons; 10-year rental, installed--$19,537, including appropriate change parts, forming heads, carton tracks, etc.

p/ Approximately 7,000-pounds-per-hour capacity; installed--$3,019.

q/ Convertible for retail and institutional cartons; prices include change parts for conversion to either style of package and drive assembly. Type A: 16 pocket; 5,000-pounds-per-hour capacity; installed--$5,200. Type B: 20 pocket; 6,000-pounds-per-hour capacity; installed--$6,240. Type C: 30 pocket; 7,000-pounds-per-hour capacity; installed--$7,250.

TABLE S-17

Frozen Snap Bean Plants--Preparation Stages: Crew Requirements in Relation to Selected Rates of Output California, 1960

Rates of output[a/]	Crew requirements[b/]								
	Feed graders	Attend graders	Feed snippers	Inspect (dry)	Cutter man	Attend blanchers	Attend boilers	Inspect (wet)	Total
pounds per hour	number of workers								
2,000	1	1	1	2	1	1	1	2	10
4,000	2	1	2	4	1	1	1	3	15
6,000	3	1	3	6	2	1	1	4	21
8,000	4	1	4	8	2	1	1	6	27
10,000	5	1	5	10	2	1	1	7	32
12,000	6	1	6	12	3	2	2	8	40
14,000	7	1	7	14	3	2	2	10	46
16,000	8	1	8	16	4	2	2	11	52
18,000	9	1	9	18	4	2	2	12	57
20,000	10	1	10	20	4	2	2	14	63

a/ Pack-out basis.

b/ Labor production standards and wage rates: Feed graders--2,000 pounds per hour; hourly wage--\$1.94. Attend graders--20,000 pounds per hour; hourly wage--\$1.94. Feed snippers--2,000 pounds per hour; hourly wage--\$1.94. Inspect (dry)--1,000 pounds per hour; hourly wage--\$1.77. Cutter man (cutting and slicing machines)--5,000 pounds per hour; hourly wage--\$1.94. Attend blanchers--10,000 pounds per hour; hourly wage--\$2.28. Attend boilers--10,000 pounds per hour; hourly wage--\$2.86. Inspect (wet)--1,500 pounds per hour; hourly wage--\$1.77.

TABLE S-18

Frozen Snap Bean Plants--Preparation Stages: Equipment Requirements in Relation to Selected Rates of Output
California, 1960 a/

Rates of output b/	Bin dumpers c/	Feed hoppers d/	Size graders e/	Cross conveyors f/		Flight conveyors g/		Feed hoppers d/	Bin dumpers c/	Snippers h/	Cutters i/	Slitters j/	Shaker-washers k/	Cross conveyors l/		Feed conveyors m/		Blanch assembly n/				Cooling assembly o/	Steam data		
																		Type A		Type B			Boilers p/	Steam	Heating surface
pounds per hour	number	feet	number	number	feet	number	feet	feet	number					number	feet	number	feet	number	feet	number	feet	number	horse-power	pounds	square feet
2,000	1	13	2	3	39	3	30	13	1	2	1	1	1	4	32	2	20	2	40	q/		2	20	690	108
4,000	1	25	4	3	75	3	30	25	1	4	2	2	2	4	64	2	20	2	40			2	20	690	108
6,000	1	37	6	3	111	3	30	37	1	6	3	3	3	4	96	2	20			2	45	2	50	1,725	270
8,000	1	49	8	3	147	3	30	49	1	8	4	4	4	4	128	2	20	2	60			2	50	1,725	270
10,000	2	61	10	3	183	3	30	61	1	10	5	5	5	4	160	2	20			2	74	2	50	1,725	270
12,000	2	73	12	3	219	3	30	73	2	12	6	6	6	4	192	2	20			2	90	2	74	2,453	400
14,000	2	85	14	3	255	3	30	85	2	14	7	7	7	4	224	2	20			2	104	2	74	2,453	400
16,000	3	97	16	3	291	3	30	97	2	16	8	8	8	6	256	3	56			3	135	3	74	2,453	400
18,000	3	109	18	3	327	3	30	109	2	18	9	9	9	6	288	3	56			3	135	3	81	2,794	437
20,000	3	121	20	3	363	3	30	121	2	20	10	10	10	6	320	3	56			3	156	3	81	2,794	437

a/ Equipment capacities and requirements calculated to provide preparation facilities at the rates indicated for either crosscut or sliced snap beans.

b/ Pack-out basis.

c/ Cradle-type mechanical dump; 3/4 h.p.; fitted with skids for movement with fork truck; 10,000-pounds-per-hour capacity; installed--$690.

d/ 5' wide x 2' deep; welded construction; custom built--$10 per foot.

e/ Double graders; three size segregations; 1,200-pounds-per-hour capacity; installed--$2,150.

f/ To collect graded beans; conveyors are driven by a single drive assembly. For lengths below 50 feet--1-h.p. motor and drive; installed--$347 + $30.90L, where L is the length of conveyor frame in feet. For lengths from 50 to 100 feet--2-h.p. motor and drive; installed--$425 + $30.90L. For lengths from 100 to 200 feet--3-h.p. motor and drive; installed--$474 + $30.90L. For lengths from 200 to 300 feet--4-h.p. motor and drive; installed--$534 + $30.90L. For lengths above 300 feet--5-h.p. motor and drive; installed--$594 + $30.90L.

g/ 12" x 10'; 2-inch cleats; installed--$547 + $15L.

h/ Two screens for small-medium and medium-large sizes; 1,000-pounds-per-hour capacity. Snipper includes picking table 24" x 12' with 1/2-h.p. motor and drive. Snipper complete with 1-h.p. snipper drive; installed--$4,007.

i/ 2,000-pounds-per-hour capacity; installed--$1,193.

j/ 2,000-pounds-per-hour capacity; 5-h.p. motor and drive, which also drives shaker-washer; installed--$2,929.

k/ Driven by slitter motor; 2,000-pounds-per-hour capacity; installed--$890.

l/ 12" x indicated lengths. Price is $10.30L plus cost of drive assembly. 1/2-h.p. motor and drive, installed--$247; 3/4-h.p. motor and drive, installed--$280; 1-h.p. motor and drive, installed--$347; 1-1/2-h.p. motor and drive, installed--$417.

m/ Flight type, leading to blanchers; installed--$547 + $15L.

n/ Requirements for both cut and sliced snap beans based on a 4-minute blanching time. Type A--36-inch galvanized woven wire draper; enclosed welded steel tank; two 1-inch water inlets; two 2-inch steam inlets; two exhaust stacks; two 3-inch drains; 3-h.p. variable-speed motor and drive; maximum length with two steam banks, 60 feet. Cost per blanching unit ($3,416) is estimated on the basis of standard 30-foot length less $86 per foot of length less than 30 feet and plus $114 per foot of length greater than 30 feet. Total installed cost includes dual-temperature control installation--$686; tax--3 percent; contingencies--10 percent; installation; and freight. Type B--same as Type A unit except draper is 48 inches wide. Cost per Type B blanching unit ($4,416) is estimated on the basis of standard 30-foot length less $111 per foot of length less than 30 feet and plus $148 per foot of length greater than 30 feet. Other costs are the same as for Type A unit.

o/ Flood type; 42" x 16' galvanized woven wire draper with 1-h.p. motor and drive; welded steel tank with 10-h.p. booster and recirculating pump; overhead pressure nozzles; custom built and installed--$4,172.

p/ Includes 125-pounds-per-square-inch Scotch marine dryback boiler, forced draft natural gas burner, feed-pump assembly, trim and fittings, and lagging and stack. Does not include steam piping and fittings to plant outlets. Installed costs of boiler units: 20 h.p.--$3,063; 50 h.p.--$4,313; 74 h.p.--$5,594; and 81 h.p.--$7,219.

q/ Blanks indicate does not apply.

TABLE S-19

Frozen Snap Bean Plants--Packaging Stages: Crew Requirements in Relation to Selected Rates of Output and Styles of Pack California, 1960

Rates of output a/	CUT SNAP BEANS													
	Retail style b/							Institutional style c/						
	Feed cartons	Attend fill	Check-weigh	Tray off	Truck skids	Supply materials	Total	Feed cartons	Attend fill	Check-weigh	Tray off	Truck skids	Supply materials	Total
pounds per hour	number of workers													
2,000	--d/	1	3	1	--	1	6	--	1	2	1	--	1	5
4,000	1	2	5	2	1	1	12	1	1	4	1	1	1	9
6,000	2	3	8	2	1	1	17	1	1	6	1	1	1	11
8,000	2	3	10	3	1	1	20	1	1	8	2	1	1	14
10,000	2	4	13	4	1	1	25	1	1	10	2	1	1	16
12,000	3	5	15	4	1	1	29	2	2	12	2	1	1	20
14,000	3	6	18	5	2	2	36	2	2	14	3	1	2	24
16,000	4	7	20	5	2	2	40	2	2	16	3	1	2	26
18,000	4	8	23	6	2	2	45	2	2	18	3	1	2	28
20,000	4	8	26	7	2	2	49	2	2	20	4	1	2	31

Rates of output a/	Bulk style e/								
	Feed trays	Attend fill	Tray off	Truck skids	Dump to cluster breaker	Fill bags	Set off	Supply materials	Total
pounds per hour	number of workers								
2,000	--	1	1	1	1	1	1	1	7
4,000	1	1	1	1	1	1	1	1	8
6,000	1	1	1	1	1	1	1	1	8
8,000	1	1	1	1	2	2	2	1	11
10,000	1	1	1	1	2	2	2	1	11
12,000	2	2	2	1	2	2	2	1	14
14,000	2	2	2	1	3	3	3	1	17
16,000	2	2	2	1	3	3	3	1	17
18,000	2	2	2	1	3	3	3	1	17
20,000	2	2	2	1	4	4	4	1	20

Rates of output a/	SLICED SNAP BEANS													
	Retail style b/							Institutional style c/						
	Feed cartons	Attend fill	Check-weigh	Tray off	Truck skids	Supply materials	Total	Feed cartons	Attend fill	Check-weigh	Tray off	Truck skids	Supply materials	Total
pounds per hour	number of workers													
2,000	--	1	3	1	--	1	6	--	1	2	1	--	1	5
4,000	1	2	5	2	1	1	12	1	1	4	1	1	1	9
6,000	2	3	8	2	1	1	17	1	1	6	1	1	1	11
8,000	2	3	10	3	1	1	20	1	1	8	2	1	1	14
10,000	2	4	13	4	1	1	25	1	1	10	2	1	1	16
12,000	3	5	15	4	1	1	29	2	2	12	2	1	1	20
14,000	3	6	18	5	2	2	36	2	2	14	3	1	2	24
16,000	4	7	20	5	2	2	40	2	2	16	3	1	2	26
18,000	4	8	23	6	2	2	45	2	2	18	3	1	2	28
20,000	4	8	26	7	2	2	49	2	2	20	4	1	2	31

a/ Converted to pounds per hour on the basis of 10-ounce retail cartons, $2\frac{1}{2}$-pound institutional cartons, 50-pound bags or cases, and 20-pound trays.

b/ Labor production standards and wage rates--retail style cut and sliced snap beans: Feed cartons--5,000 pounds per hour; hourly wage--$1.77. Attend fill--2,500 pounds per hour; hourly wage--$1.77. Check-weigh--the standard for hand weighing varies according to the position of the worker in the weigh line as given in the following equation: $Y = 760.2 - 51.13X$, where Y is pounds per worker hour and X is the line position of the worker; hourly wage--$1.77. Tray off--3,200 pounds per hour; hourly wage--$1.94. Supply materials and truck skids--12,200 pounds per hour; hourly wage--$1.94.

c/ Labor production standards and wage rates--institutional style cut and sliced snap beans: Hourly wage rates are the same as for retail style. Feed cartons and attend fill--10,000 pounds per hour. Check-weigh--1,000 pounds per hour. Tray off--6,400 pounds per hour. Truck skids--20,000 pounds per hour. Supply materials--12,000 pounds per hour.

d/ Dashes indicate job performed by another worker at this output rate.

e/ Labor production standards and wage rates--bulk style cut snap beans: Hourly wage rates are the same for all jobs--$1.94. Feed trays and attend fill--10,000 pounds per hour. Tray off--12,200 pounds per hour. Truck skids--20,000 pounds per hour. Dump to cluster breaker, fill bags or cases with IQF cuts, and set off bulk containers to pallets--6,000 pounds per hour. Supply materials--20,000 pounds per hour.

TABLE S-20

Frozen Snap Bean Plants--Packaging Stages: Equipment Requirements in Relation to Selected Rates of Output and Styles of Pack
California, 1960

Rates nf output a/	Common equipment: Scales and pans b/	Common equipment: Diatribution conveyors c/: Cross		Common equipment: Diatribution conveyors c/: Flight		Cut snap beans, Retail style: Inspection lines d/		Cut snap beans, Retail style: Weigh lines e/		Cut snap beans, Retail style: Wrappers f/	Cut snap beans, Retail style: Fillers g/: Type A	Fillers g/: Type B	Fillers g/: Type C	Cut snap beans, Retail style: Carton equipment h/	Cut snap beans, Institutional style: Weigh lines e/		Institutional style: Wrappers i/	Institutional style: Fillers j/: Type A	Fillers j/: Type B	Institutional style: Carton equipment k/	Bulk style: Filling assembly l/	Sliced snap beans, retail and institutional styles: Weigh lines e/		Sliced: Fillers m/: Type A	Fillers m/: Type B	Fillers m/: Type C	Sliced: Wreppers: Reteil f/	Wreppers: Institutional i/	Sliced: Certon equipment n/
pounds per hour	number	number	feet	number	feet	number	feet	number	feet	number	number	number	number	number	number	feet	number	number	number	number	number	number	feet	number	number	number	number	number	number
2,000	4	4	53	4	40	1	8	1	8	1	1	o/		1	1	8	1	1		1	1	1	8	1			1	1	1
4,000	8	4	53	4	40	1	8	1	12	1	1			1	1	8	1	1		1	1	1	8	1			1	1	1
6,000	14	4	58	4	40	1	8	1	20	1		1		1	1	12	1	1		1	1	1	8		1		1	1	1
8,000	16	6	83	6	60	2	16	2	24	2	2			2	1	14	1	1		1	1	2	16	2			2	1	2
10,000	22	6	83	6	60	2	16	2	30	2	2			2	1	17	1		1	1	1	2	16	2			2	1	2
12,000	28	6	91	6	60	2	16	2	40	2		2		2	1	20	1		1	1	2	2	16		2		2	1	2
14,000	36	6	101	7	70	2	16	2	50	2			2	2	2	24	2	2		2	2	2	16			2	2	2	2
16,000	36	7	129	10	100	3	24	3	51	3	2	1		3	2	26	2	2		2	2	3	24	3			3	2	3
18,000	42	7	139	10	100	3	24	3	60	3		3		3	2	28	2	2		2	2	3	24		3		3	2	3
20,000	48	7	144	10	100	3	24	3	66	3		1	2	3	2	32	2		2	2	2	3	24		1	2	3	2	3

a/ Pack-out basis.

h/ Scales of 3-pound capacity; 1 ounce over and under by 1/4-ounce dial; knife-edge pivots; platter and base of polished cast aluminum; anticorrosion treated; delivered--$176 eacb. Product pans, aluminum; $2.00 each.

c/ To fill stations. Cross conveyors 12" x indicated lengths; 3/4-h.p. motnr and drive; wire mesh; installed--$280 + $15L, where L is the length of conveyor frame in feet. Flight conveyors to fill hoppers--$547 + $15L.

d/ 24" x indicatad lengths--$280 + $15L.

e/ Two conveyors, each 6" x indicated lengths, with iotegrated weighing stands. Filled carton delivery conveyor is 2 to 3 inches above scale platters; installed--$1,094 + $50L.

f/ 7,500-pounds-per-hour capacity; installed--$12,245.

g/ Straight-line, semiautomatic filler assembly. Type A--16 pocket; 5,000-pounds-per-hour capacity; installed--$3,784. Type B--20 pocket; 6,000-pounds-per-hour capacity; installed--$4,541. Type C--30 pocket; 7,000-pounds-per-hour capacity; installed--$6,190.

h/ Kliklok-type carton-forming, Prespak, and closing assembly; 7,500-pounds-per-hour capacity; 10-year rental--$18,186.

i/ 12,750-pounds-per-hour capacity; installed--$10,500.

j/ Straight-line, semiautomatic filler assembly. Type A--16 pocket; 8,000-pounds-per-hour capacity; installed--$3,784. Type B--20 pocket; 12,000-pounds-per-hour capacity; installed--$4,541.

k/ Kliklok-type cartoo-forming, Prespak, and closing assembly; 12,750 pounds-per-bour capacity; 10-year rental--$17,426.

l/ Bulk tray-fill and bagging assembly. Includes: (1) tray-fill assembly--witb tray-fill hopper, vibrator feed mechanism, powered roller conveyor (cleated for trays), two-speed motor and drive assembly, and take-off skate-wheel conveyor; 10,000-pounds-per-hour capacity; custom built and installed--$1,823. (2) Cluster separator--1-h.p. motor; 10,000-pounds-per-hour capacity; custom built and installed--$1,200. (3) Spiral cooveyor for deliveriog IQF cuts to bag or case filler--15 feet long with 9-inch screw; enclosed; 1-h.p. motor and drive; installed--$498 each. (4) Bag or case filler--60-pound maximum fill each; manually operated; includes bopper, spiral feed mechanism, shear gate, and hand lever; custom built and installed--$672.

m/ Straight-line, semiautomatic filler assembly; convertible for retail or inatitutional cartons. Type A--16 pocket; 5,000-pounds-per-hour capacity; installed--$5,562. Type B--20 pocket; 6,000-pounds-per-bour capacity; installed--$6,602. Type C--30 pocket; 7,000-pounds-per-hour capacity; installed--$7,612.

n/ Kliklok-type carton-forming, Prespak, and closing assembly; convertible for retail and institutional cartons; 10-year rental--$19,537, including appropriate change parts, forming heads, carton tracks, etc.

o/ Blanks indicate does not apply.

TABLE S-21

Frozen Spinach Plants--Preparation Stages: Equipment and Crew Requirements in Relation to Selected Rates of Output
California, 1960

Rates of output a/	Equipment requirements																		
	Dump conveyors b/		Flight conveyors c/		Dry reels d/	Flight conveyors c/		Cross conveyors e/		Dry inspection belts f/		Cross conveyors g/		Cross conveyors h/		Wash assembly i/ Type A	Wash assembly i/ Type B	Wilt tanks j/
pounds per hour	number	feet	number	feet	number	number	feet	number	feet	number	feet	number	feet	number	feet	number	number	number
2,000	1	15	1	12	1	1	12	p/		1	10					1	1	1
4,000	1	15	1	12	1	1	12	1	10	2	20	1	10	1	8	1	1	1
6,000	1	15	1	12	1	1	12	1	22	3	30	1	22	1	8	1	1	1
8,000	2	30	2	24	2	2	24	2	20	4	40	2	20	2	16	2	2	2
10,000	2	30	2	24	2	2	24	2	32	5	50	2	32	2	16	2	2	2
12,000	2	30	2	24	2	2	24	2	42	6	60	2	42	2	16	2	2	2
14,000	2	30	2	24	2	2	24	2	44	7	70	2	44	2	16	2	2	2
16,000	3	45	3	36	3	3	36	3	54	8	80	3	54	3	24	2	2	3
18,000	3	45	3	36	3	3	36	3	64	9	90	3	64	3	24	2	2	3
20,000	3	45	3	36	3	3	36	3	66	10	100	3	66	3	24	2	2	3

Rates of output a/	Equipment requirements (continued)								Crew requirements n/					
	Blanch assembly k/ Type A		Blanch assembly k/ Type B		Cooling tanks l/	Steam data: Boiler m/	Steam data: Steam	Steam data: Heating surface	Hand fork	Yard man and attendant	Dry-belt quality sort	Attend blanchers	Attend boilers	Total o/
pounds per hour	number	feet	number	feet	number	horsepower	pounds	square feet	number of workers					
2,000	1	12			1	20	690	108	1	1	2	1	1	6
4,000	1	23			1	20	690	108	1	1	4	1	1	8
6,000			1	25	1	50	1,725	270	1	1	6	1	1	10
8,000	2	23			2	50	1,725	270	2	1	8	1	1	13
10,000			2	21	2	50	1,725	270	2	1	10	1	1	15
12,000			2	25	2	74	2,453	400	2	2	12	2	2	20
14,000			2	30	2	74	2,453	400	3	2	14	2	2	23
16,000			3	25	3	74	2,453	400	3	2	16	2	2	25
18,000			3	25	3	81	2,794	437	3	2	18	2	2	27
20,000			3	30	3	81	2,794	437	4	2	20	2	2	30

a/ Pack-out basis.

b/ 24" x 15'; 1-inch cleats, 12 inches on center; 24-inch inclined siding; 3/4-h.p. motor and drive; installed--$547 + $15L, where L is the length of conveyor frame in feet.

c/ 24" x 12'; 3-inch cleats; 24-inch siding; 3/4-h.p. motor and drive; installed--$547 + $15L.

d/ Galvanized woven wire drum; 60" x 11'; 2-h.p. motor; installed--$2,736 each.

e/ Drag type, sliding chain; flights 15 inches on center; 24-inch pan with openings over each inspection conveyor; installed--$547 + $20L.

f/ 24" x 10'; waste disposal chutes; 6-inch sidings; 3/4-h.p. motor; installed--$280 + $15.30L.

g/ To washers; 15" x indicated lengths; cleated; 6-inch sidings; 3/4-h.p. motor; installed--$280 + $15.30L.

h/ To washers; 10" x 8' each; cleated; 6-inch sidings; 3/4-h.p. motor; installed--$280 + $15.30L.

i/ Flood-type washers; Types A and B in tandem. Type A--42" x 16'; galvanized woven wire draper with 1-h.p. motor and drive; welded steel tank with 10-h.p. booster and recirculating pump; overhead pressure nozzles; custom built and installed--$4,172. Type B--same as Type A except tank is 42" x 22' and pump is 20 h.p.; custom built and installed--$5,749.

j/ 42" x 16' with steam manifold; installed--$4,170.

k/ Requirements based on a 1½-minute blanching time. Type A--36-inch galvanized woven wire draper; enclosed welded steel tank; two 1-inch water inlets; two 2-inch steam inlets; two exhaust stacks; two 3-inch drains; 3-h.p. variable-speed motor and drive; maximum length with two steam banks, 60 feet. Cost per blanching unit ($3,416) is estimated on the basis of standard 30-foot length less $66 per foot of length less than 30 feet and plus $114 per foot of length more than 30 feet. Total installed cost includes dual temperature control installation, $686; tax, 3 percent; contingencies, 10 percent; installation; and freight. Type B--same as Type A except draper is 48 inches. Cost per Type B blanching unit ($4,416) is estimated on the basis of standard 30-foot length less $111 per foot of length less than 30 feet and $148 per foot of length more than 30 feet. Other costs are the same as for Type A unit.

l/ Same type as Type A washer; installed--$4,172.

m/ Includes 125-pounds-per-square-inch Scotch marine dryback boiler, forced draft natural gas burner, feed-pump assembly, trim and fittings, and lagging and stack. Does not include steam piping and fittings to plant outlets. Installed costs of boiler unit: 20 h.p.--$3,063; 50 h.p.--$4,313; 74 h.p.--$5,594; and 81 h.p.--$7,219.

n/ Labor production standards and wage rates: Hand fork--6,000 pounds per hour; hourly wage--$1.94. Yard man and equipment attendant--10,000 pounds per hour; hourly wage--$2.28. Dry-belt quality sort--1,000 pounds per hour; hourly wage--$1.77. Blancher and cleaning equipment attendant--10,000 pounds per hour; hourly wage--$2.28. Fire and boiler attendant--10,000 pounds per hour; hourly wage--$2.56.

o/ Supervision, housekeeping, and utility labor included in a separate stage analysis.

p/ Blanks indicate does not apply.

TABLE S-22

Frozen Spinach Plants--Packaging Stages: Crew Requirements in Relation to Selected Rates of Output, Styles of Pack, and Methods Used California, 1960

Rates of output[a]	Inspect[b]	Leaf spinach: Retail style[c]: Feed cartons	Pack	Weigh	Supply materials	Truck skids	Tray off	Total	Leaf spinach: Institutional style[d]: Feed cartons, Method A	Feed cartons, B	Pack, A	Pack, B	Weigh, A	Weigh, B	Supply materials, A	Supply materials, B	Truck skids, A	Truck skids, B	Tray off, A	Tray off, B	Total, A	Total, B
pounds per hour	number of workers																					
2,000	3	--[e]	3	4	1	1	1	10	--	[f]	2	4	3	5	1	1	1	1	1	1	8	12
4,000	6	1	5	8	1	1	2	18	1		4	7	6	9	1	2	1	1	1	1	14	20
6,000	8	1	7	13	1	1	2	25	1		6	10	8	13	1	3	1	1	1	1	18	28
8,000	11	2	10	16	1	1	3	33	1		8	14	11	17	1	3	1	1	2	2	24	37
10,000	13	2	12	24	1	1	4	41	1		9	17	14	21	1	3	1	1	2	2	28	44
12,000	16	2	14	26	1	1	4	48	1		11	20	16	25	1	4	1	1	2	2	32	52
14,000	19	2	18	33	2	2	5	62	2		13	23	19	29	2	4	1	1	3	3	40	60
16,000	21	3	19	33	2	2	5	64	2		15	27	22	34	2	5	1	1	3	3	45	70
18,000	24	3	21	39	2	2	6	73	2		17	30	24	38	2	6	1	1	3	3	49	78
20,000	26	3	25	43	2	2	7	82	2		18	33	27	42	2	6	1	1	4	4	54	86

Rates of output	Chopped spinach: Retail style[g]: Feed cartons	Attend fill	Check-weigh	Supply materials	Truck skids	Tray off	Total	Chopped spinach: Institutional style[h]: Feed cartons	Attend fill	Check-weigh	Supply materials	Truck skids	Tray off	Total
	number of workers													
2,000	--	1	1	1	1	1	5	--	1	1	1	1	1	5
4,000	1	1	1	1	1	2	7	1	1	1	1	1	1	6
6,000	1	1	1	1	1	2	7	1	1	1	1	1	1	6
8,000	2	2	2	1	1	3	11	1	2	2	1	1	2	9
10,000	2	2	2	1	1	4	12	1	2	2	1	1	2	9
12,000	2	2	2	1	1	4	12	1	2	2	1	1	2	9
14,000	2	2	2	2	2	5	15	2	2	2	2	1	3	12
16,000	3	3	3	2	2	5	18	2	3	3	2	1	3	14
18,000	3	3	3	2	2	6	19	2	3	3	2	1	3	14
20,000	3	3	3	2	2	7	20	2	3	3	2	1	4	15

a/ Converted to pounds per hour on the basis of 10-ounce retail cartons and 25-pound institutional cartons.

b/ Common to all styles--774 pounds per hour; hourly wage--$1.77.

c/ Labor production standards and wage rates--retail style leaf spinach: Feed cartons--7,500 pounds per hour; hourly wage--$1.77. Pack--the standard for hand packing varies according to the position of the worker in the packing line as given in the following equation: $Y = 1{,}013.2 - 75.93X$, where Y is pounds per worker hour and X is the line position of the worker; hourly wage--$1.77. Weigh--the standard for hand weighing varies according to the position of the worker in the weigh line as given in the following equation: $Y = 556.8 - 26.58X$, where Y and X have the same meaning as above; hourly wage--$1.77. Supply materials and truck skids--12,000 pounds per hour; hourly wage--$1.94. Tray off--3,200 pounds per hour; hourly wage--$1.94.

d/ Labor production standards and wage rates--institutional style leaf spinach (Method A): Wage rates are the same as for retail leaf spinach. Feed cartons--12,000 pounds per hour. Pack--1,053 pounds per hour. Weigh--750 pounds per hour. Supply materials--12,000 pounds per hour. Truck skids--20,000 pounds per hour. Tray off--6,375 pounds per hour.

Labor production standards and wage rates--institutional style leaf spinach (Method B): Wage rates are the same as for retail leaf spinach. Feed cartons--does not apply with this method. Pack--612 pounds per hour. Weigh--484 pounds per hour. Supply materials--3,500 pounds per hour. Truck skids--20,000 pounds per hour. Tray off--6,375 pounds per hour.

e/ Dashes indicate job performed by another worker at this output rate.

f/ Blanks indicate does not apply.

g/ Labor production standards and wage rates--retail style chopped spinach: Wage rates are the same as for retail leaf spinach. Feed cartons, attend fill, check-weigh, and supply materials--7,500 pounds per hour. Truck skids--12,000 pounds per hour. Tray off--3,200 pounds per hour.

h/ Labor production standards and wage rates--institutional style chopped spinach: Wage rates are the same as for retail leaf spinach. Feed cartons and supply materials--12,000 pounds per hour. Attend fill and check-weigh--7,500 pounds per hour. Truck skids--20,000 pounds per hour. Tray off--6,375 pounds per hour.

TABLE S-23

Frozen Spinach Plants--Packaging Stages: Equipment Requirements in Relation to Selected Rates of Output, Styles of Pack, and Methods Used California, 1960

Rates of output a/	Leaf spinach																				
	Common equipment					Retail style					Institutional style										
								Carton equipment			Method A						Method B				
	Inspection lines b/		Pack lines b/		Scales and pans c/	Weigh lines d/		Formers e/	Convergers f/	Wrappers g/	Cross conveyors h/		Weigh lines d/		Carton equipment i/	Wrappers j/	Cross conveyors h/		Weigh lines d/		Wrappers j/
pounds per hour	number	feet	number	feet	number	number	feet	number			number	feet	number	feet	number		number	feet	number	feet	number
2,000	1	8	1	8	4	1	8	1	1	1	1	10	1	8	1	1	1	10	1	10	1
4,000	1	10	1	10	8	1	12	1	1	1	1	10	1	10	1	1	1	10	1	15	1
6,000	1	12	1	12	13	1	20	1	1	1	1	10	1	12	1	1	1	10	1	20	1
8,000	2	20	2	20	16	2	24	2	2	2	2	20	2	20	1	1 k/	2	20	2	30	1
10,000	2	24	2	20	21	2	34	2	2	2	2	20	2	24	1	1 k/	2	20	2	34	1
12,000	2	24	2	24	26	2	40	2	2	2	2	20	2	24	1	1 k/	2	20	2	40	1
14,000	2	30	2	30	33	2	44	2	2	2	2	20	2	30	2	2	2	20	2	44	2
16,000	3	36	3	36	33	3	51	3	3	3	3	30	3	36	2	2 l/	3	30	3	96	2
18,000	3	36	3	36	39	3	60	3	3	3	3	30	3	36	2	2 l/	3	30	3	105	2
20,000	3	45	3	45	43	3	66	3	3	3	3	30	3	45	2	2 l/	3	30	3	111	2

Rates of output a/	Chopped spinach																
	Common equipment						Retail style						Institutional style				
	Cross conveyors m/		Feed conveyors n/		Choppers o/	Carton equipment p/	Spiral conveyors q/		Automatic fillers r/			Wrappers g/	Spiral conveyors q/		Automatic fillers s/		Wrappers j/
									Type A	Type B	Type C				Type A	Type B	
pounds per hour	number	feet	number	feet	number		number	feet	number				number	feet	number		
2,000	1	8	1	8	1	1	1	10	1	t/		1	1	10	1		1
4,000	1	8	1	8	1	1	1	10		1		1	1	10	1		1
6,000	1	8	1	8	1	1	1	10			1	1	1	10		1	1
8,000	2	16	2	16	2	2	2	20		2		2	2	20	2		1
10,000	2	16	2	16	2	2	2	20	1		1	2	2	20	1	1	1
12,000	2	16	2	16	2	2	2	20		1	1	2	2	20	1	1	1
14,000	2	16	2	16	2	2	2	20			2	2	2	20		2	2
16,000	3	24	3	24	3	3	3	30		2	1	3	3	30	2	1	2
18,000	3	24	3	24	3	3	3	30		2	1	3	3	30	2	1	2
20,000	3	24	3	24	3	3	3	30		1	2	3	3	30		3	2

a/ Pack-out basis.

b/ Drive for packing belt also drives inspection belt; includes 30-inch product conveyor with 6-inch side tracks for retail cartons and an institutional carton conveyor 12 inches above center of product belt; two 2-h.p. motors and drives; installed, including inspection (wet) belt, dewater compressor, and packing belt--$1,144 + $50L, where L is the length of conveyor frame in feet.

c/ Scales of 3-pound capacity; 1 ounce over and under by 1/4-ounce dial; knife-edge pivots; platter and base of polished cast aluminum; anticorrosion treated; delivered--$176 each. Product pans, aluminum; $2.00 each.

d/ Three carton conveyors, each 6" x indicated lengths; scales mounted between conveyors; installed--$1,094 + $50L.

e/ Kliklok-type carton-forming, Prespak, and closing sections; approximately 8,500-pounds-per-hour capacity; 10-year rental--$13,277.

f/ One carton converger--$480; three turn units--$159; installed cost for each line--$639.

g/ 8,500-pounds-per-hour capacity; installed--$12,245, including tray-off attachment.

h/ To institutional weigh line; two turn units; installed--$453 + $10.30L.

i/ Kliklok-type carton-forming, Prespak, and closing sections; approximately 12,750-pounds-per-hour capacity; 10-year rental--$13,279.

j/ 12,750-pounds-per-hour capacity; installed--$10,500, including tray-off attachment.

k/ Includes one 12-foot feeder conveyor, two turn units, and one converger; wrapper and feed assembly--$11,588.

l/ Includes one 20-foot feeder conveyor, three turn units, two convergers, and two motors and drives; complete assembly--$22,929.

m/ To chop line; 12" x indicated lengths; 3/4-h.p. motor and drive; installed--$280 + $10.30L.

n/ 12" x 8'; 3/4-h.p. motor and drive; installed--$280 + $10.30L.

o/ Urschel; 5-h.p. motor and drive; approximately 7,500 to 8,500 pounds-per-hour capacity; installed--$3,096, including discharge hopper.

p/ Convertible for retail and institutional cartons; 10-year rental, installed--$19,537, including appropriate change parts, forming heads, carton tracks, etc.

q/ To automatic fillers; installed--$280 + $14.50L.

r/ All prices include fill hopper, tie-in with carton former, freight, and taxes. Type A--single cylinder, mechanical throw; 2,400-pounds-per-hour capacity; installed--$1,980. Type B--twin cylinder, pneumatic throw; 4,800-pounds-per-hour capacity; installed--$3,673. Type C--pocket plunger type; 10 pockets; approximately 8,500-pounds-per-hour capacity; installed--$5,998.

s/ All prices include fill hopper, tie-in with carton former, freight, and taxes. Type A--single cylinder, mechanical throw; approximately 4,500-pounds-per-hour capacity; installed--$1,980. Type B--twin cylinder, pneumatic throw; approximately 9,000-pounds-per-hour capacity; installed--$3,673.

t/ Blanks indicate does not apply.

TABLE S-24

Frozen Broccoli and Spinach Processing with Partially Adaptable Equipment: Common and Specialized Preparation and Packaging Equipment Requirements for Nonsimultaneous Operations in Relation to Selected Rates of Output and Styles of Pack
California, 1960

PREPARATION — Specialized equipment[b]

Rates of output[a]	Broccoli							Spinach					
	Bin dumpers	Conveyors				Bypass wilt tank		Dry reels	Wilt tanks	Conveyors			
		Apron		Return and cross						Dump		Flight	
pounds per hour	number	number	feet	number	feet	number	feet	number	number	number	feet	number	feet
2,000	1	1	8	2	43	1	16	1	1	1	15	1	12
4,000	1	1	8	2	50	1	16	1	1	1	15	1	12
6,000	1	1	8	2	60	1	16	1	1	1	15	1	12
8,000	2	2	16	4	100	2	32	2	2	2	30	2	24
10,000	2	2	16	4	110	2	32	2	2	2	30	2	24
12,000	2	2	16	4	120	2	32	2	2	2	30	2	24
14,000	2	2	16	4	125	2	32	2	2	2	30	2	24
16,000	3	3	24	6	170	3	48	3	3	3	45	3	36
18,000	3	3	24	6	180	3	48	3	3	3	45	3	36
20,000	3	3	24	6	185	3	48	3	3	3	45	3	36

PREPARATION — Common equipment

Rates of output[a]	Trim table assembly		Conveyors												Wash assembly		Blanch assembly				Cooling tanks	Steam data		
			Flight		Cross		Waste		Wash		Blanch		Drain		Type A	Type B	Type A		Type B			Boilers	Steam	Heating surface
pounds per hour	number	feet	number	feet	number	feet	number	feet	number	feet	number	feet	number	feet	number	number	number	feet	number	feet	number	horsepower	pounds	square feet
2,000	1	25	1	15	c/		2	55	1	8	1	10	1	10	1	1	1	20			1	20	690	108
4,000	2	50	1	15	1	15	3	80	2	18	1	10	1	10	1	1	1	40			1	20	690	108
6,000	3	75	1	15	1	25	4	105	2	30	1	10	1	10	1	1			1	45	1	50	1,725	270
8,000	4	100	2	30	2	30	5	145	4	36	2	20	2	20	2	2	2	60			2	50	1,725	270
10,000	5	125	2	30	2	40	6	170	4	48	2	20	2	20	2	2			2	74	2	50	1,725	270
12,000	6	150	2	30	2	50	7	195	4	58	2	20	2	20	2	2			2	90	2	74	2,453	400
14,000	7	175	2	30	2	55	8	220	4	60	2	20	2	20	2	2			2	104	2	74	2,453	400
16,000	8	200	3	45	3	65	9	260	6	78	3	56	3	30	2	2			3	135	3	74	2,453	400
18,000	9	225	3	45	3	75	10	285	6	88	3	56	3	30	2	2			3	135	3	81	2,794	437
20,000	10	250	3	45	3	80	11	311	6	90	3	56	3	30	2	2			3	156	3	81	2,794	437

PACKAGING — Common equipment

Rates of output[a]	All forms and styles					Broccoli spears and leaf spinach																Chopped broccoli and spinach, retail and institutional styles						
						Retail style								Institutional style														
	Scales and pans	Distribution conveyors				Inspection lines		Pack lines		Weigh lines		Wrappers	Carton equipment	Inspection and pack lines		Weigh lines		Wrappers	Carton equipment	Weigh lines		Wrappers		Choppers	Carton equipment
		Cross		Flight																		Retail	Institutional		
pounds per hour	number	number	feet	number	feet	number	feet	number	feet	number	feet	number	number	number	feet	number	feet	number	number	number	feet	number	number	number	number
2,000	4	4	53	2	20	1	8	1	8	1	8	1	1	1	8	1	8	1	1	1	8	1	1	1	1
4,000	8	4	53	2	20	1	8	1	12	1	12	1	1	1	8	1	8	1	1	1	8	1	1	1	1
6,000	14	4	58	2	20	1	8	1	20	1	20	1	1	1	12	1	12	1	1	1	8	1	1	1	1
8,000	16	6	83	3	30	2	16	2	24	2	24	2	2	1	14	1	14	1	1	2	16	2	1	2	2
10,000	22	6	83	3	30	2	16	2	30	2	30	2	2	1	17	1	17	1	1	2	16	2	1	2	2
12,000	28	6	91	3	30	2	16	2	40	2	40	2	2	1	20	1	20	1	1	2	16	2	1	2	2
14,000	36	6	101	3	30	2	16	2	50	2	50	2	2	2	24	2	24	2	2	2	16	2	2	2	2
16,000	36	7	129	4	40	3	24	3	51	3	51	3	3	2	26	2	26	2	2	3	24	3	2	3	3
18,000	42	7	139	4	40	3	24	3	60	3	60	3	3	2	28	2	28	2	2	3	24	3	2	3	3
20,000	48	7	144	4	40	3	24	3	66	3	66	3	3	2	32	2	32	2	2	3	24	3	2	3	3

PACKAGING — Specialized equipment[d]

Rates of output[a]	Chopped broccoli			Chopped spinach					
	Fillers			Feed conveyors		Fillers		Spiral conveyors	
	Type A	Type B	Type C			Type A	Type B		
pounds per hour	number	number	number	number	feet	number	number	number	feet
2,000	1			1	8	1		2	20
4,000	1			1	8	1		2	20
6,000		1		1	8		1	2	20
8,000	2			2	16	2		4	40
10,000	2			2	16	1	1	4	40
12,000		2		2	16	1	1	4	40
14,000			2	2	16		2	4	40
16,000	3			3	24	2	1	6	60
18,000		3		3	24	2	1	6	60
20,000		1	2	3	24		3	6	60

a/ Pack-out basis.

b/ For requirements, specifications, and unit prices of specialized broccoli and spinach preparation equipment, refer to Tables S-14 and S-21, respectively.

c/ Blanks indicate does not apply.

d/ For requirements, specifications, and unit prices of specialized broccoli and spinach packaging equipment, refer to Tables S-16 and S-23, respectively.

TABLE S-25

Frozen Broccoli and Snap Bean Processing with Partially Adaptable Equipment: Common and Specialized Preparation Equipment Requirements for Nonsimultaneous Operations in Relation to Selected Rates of Output and Styles of Pack California, 1960a/

Rates of output b/	Specialized equipment																									
	Broccoli				Snap beans																					
	Conveyors																	Conveyors								
	Apron		Return and cross		Bin dumpers	Feed hoppers		Size graders	Conveyors: Cross		Conveyors: Flight		Snippers	Cutters	Slitters	Shaker-washers	Distribution		Blancher feed		Drain		Type A blancher		Cooling tank
pounds per hour	number	feet	number	feet	number	number	feet	number	number	feet	number	feet	number	number	number	number	number	feet	number	feet	number	feet	number	feet	number
2,000	1	8	2	43	1	2	26	2	3	30	3	30	2	1	1	1	4	32	1	10	1	10	1	20	1
4,000	1	8	2	50	1	2	50	4	3	75	3	30	4	2	2	2	4	64	1	10	1	10	1	20	1
6,000	1	8	2	60	1	2	74	6	3	111	3	30	6	3	3	3	4	96	1	10	1	10	1	20	1
8,000	2	16	4	100	1	2	98	8	3	147	3	30	8	4	4	4	4	128	c/						
10,000	2	16	4	110	1	2	122	10	3	183	3	30	10	5	5	5	4	160							
12,000	2	16	4	120	2	3	146	12	6	219	6	60	12	6	6	6	4	192							
14,000	2	16	4	125	2	3	170	14	6	255	6	60	14	7	7	7	4	224							
16,000	3	24	6	170	2	3	194	16	6	291	6	60	16	8	8	8	6	256							
18,000	3	24	6	180	2	3	218	18	6	327	6	60	18	9	9	9	6	288							
20,000	3	24	6	185	2	3	242	20	6	363	6	60	20	10	10	10	6	320							

Rates of output b/	Common equipment																								
	Bin dumpers	Trim table assembly		Conveyors										Drain		Wash assembly		Blanch assembly				Cooling tanks	Steam data		
				Flight		Cross		Waste		Wash		Blanch				Type A	Type B	Type A		Type B			Boilers	Steam	Heating surface
pounds per hour	number	number	feet	number	feet	number	feet	number	feet	number	feet	number	feet	number	feet	number	number	number	feet	number	feet	number	horsepower	pounds	square feet
2,000	1	1	25	1	15			2	55	1	8	1	10	1	10	1	1	1	20			1	20	690	108
4,000	1	2	50	1	15	1	15	3	80	2	18	1	10	1	10	1	1	1	40			1	20	690	108
6,000	1	3	75	1	15	1	25	4	105	2	30	1	10	1	10	1	1			1	45	1	50	1,725	270
8,000	2	4	100	2	30	2	30	5	145	4	36	2	20	2	20	2	2	2	60			2	50	1,725	270
10,000	2	5	125	2	30	2	40	6	170	4	48	2	20	2	20	2	2			2	74	2	50	1,725	270
12,000	2	6	150	2	30	2	50	7	195	4	58	2	20	2	20	2	2			2	90	2	74	2,453	400
14,000	2	7	175	2	30	2	55	8	220	4	60	2	20	2	20	2	2			2	104	2	74	2,453	400
16,000	3	8	200	3	45	3	65	9	260	6	78	3	56	3	30	2	2			3	135	3	74	2,453	400
18,000	3	9	225	3	45	3	75	10	285	6	88	3	56	3	30	2	2			3	135	3	81	2,794	437
20,000	3	10	250	3	45	3	80	11	311	6	90	3	56	3	30	2	2			3	156	3	81	2,794	437

a/ Refer to Part III, Section 2, of the text for a synthesis of equipment requirements and specifications for each product.

b/ Pack-out basia.

c/ Blanks indicata does not apply.

TABLE S-26

Frozen Broccoli and Snap Bean Processing with Partially Adaptable Equipment: Common and Specialized Packaging Equipment Requirements for Nonsimultaneous Operations in Relation to Selected Rates of Output and Styles of Pack California, 1960a/

Common equipment

Rates of output b/	All forms and styles					Broccoli spears and cut snap beans								Chopped broccoli and sliced snap beans, retail and institutional styles						
	Scales and pans	Conveyors				Retail style				Institutional style				Weigh lines		Fillers		Wrappers		Carton equipment
		Cross		Flight		Weigh lines		Wrappers	Carton equipment	Weigh lines		Wrappers	Carton equipment					Retail	Institutional	
pounds per hour	number	number	feet	number	feet	number	feet	number	number	number	feet	number	number	number	feet	number	type	number	number	number
2,000	4	5	61	2	20	1	8	1	1	1	8	1	1	1	8	1	A	1	1	1
4,000	8	5	61	2	20	1	12	1	1	1	8	1	1	1	8	1	A	1	1	1
6,000	14	5	66	2	20	1	20	1	1	1	12	1	1	1	8	1	B	1	1	1
8,000	16	8	99	3	30	2	24	2	2	1	14	1	1	2	16	2	A	2	1	2
10,000	22	8	99	3	30	2	30	2	2	1	17	1	1	2	16	2	A	2	1	2
12,000	28	8	107	3	30	2	40	2	2	1	20	1	1	2	16	2	B	2	1	2
14,000	36	8	117	3	30	2	50	2	2	2	24	2	2	2	16	2	C	2	2	2
16,000	36	10	153	4	40	3	51	3	3	2	26	2	2	3	24	3	A	3	2	3
18,000	42	10	163	4	40	3	60	3	3	2	28	2	2	3	24	3	B	3	2	3
20,000	48	10	168	4	40	3	66	3	3	2	32	2	2	3	24	2 1	B C	3	2	3

Specialized equipment

Rates of output b/	Snap beans					Broccoli				
	Fillers			Flight conveyors		Packing lines				Choppers
	Retail	Institutional	Bulk			Retail		Institutional		
pounds per hour	number	number	number	number	feet	number	feet	number	feet	number
2,000	1	1	1	2	20	1	8	1	8	1
4,000	1	1	1	2	20	1	12	1	8	1
6,000	1	1	1	2	20	1	20	1	12	1
8,000	2	1	1	3	30	2	24	1	14	2
10,000	2	1	1	3	30	2	30	1	17	2
12,000	2	1	2	3	30	2	40	1	20	2
14,000	2	2	2	4	40	2	50	2	24	2
16,000	3	2	2	6	60	3	51	2	26	3
18,000	3	2	2	6	60	3	60	2	28	3
20,000	3	2	2	6	60	3	66	2	32	3

a/ Refer to Part III, Section 2, of the text for a synthesis of equipment requirements and specifictions for each product.

b/ Pack-out basis.

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